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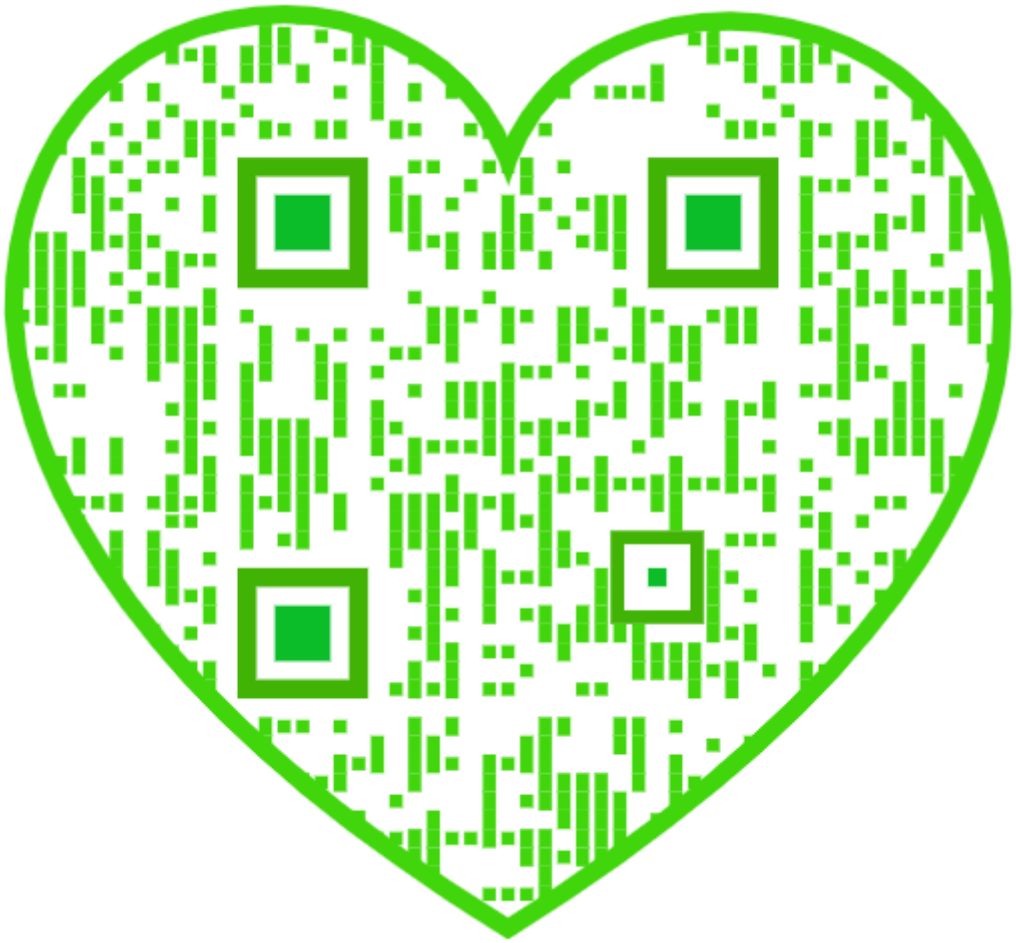

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INDEX

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INDEX

VOL. LVIII. JANUARY—JUNE, 1920

Capital Letter E refers to Editorials.

(Where page and date are both given, as 40-May, reference is made to an article in the advertising section on the page of the issue named.)

Agricultural Villages, Water Works Requirements for, by Edgar A. Rossiter.226
Air Compressor for the Contractor, A Portable .....(May) 40
Air Lift Pumps, Experiences With, by W. G. Kirchoffer 177
Albuquerque, New Mexico, Covers All Municipal Employees With Group Life Insurance 216
American Association of Engineers, Features of Annual Convention of....240
Arbitrary Engineering Standards, E. .. 97
Artesian Well Contract, Experiences In, by Jerry Donahue.....260
Article, Good, When a Man Writes, E..233
Article, The Dictated, E. 50
Asphalt and Road Oil from Tank Cars, Unloading 126
Asphalt Cement Qualities and Tests Needed in Specifications for Sheet Asphalt and Asphaltic Concrete Pavements, by J. W. Howard 236
Asphalt for Highway Work, Terms Used in Connection With 19
Asphalt Roads in New Jersey.....248
Asphalt Smoothing Iron, A Self-Heating 125
Asphaltic Roads in the Panama Canal Zone, The Construction of..... 11
Austin Combination Dragline Machine, The .....(Feb.) 34
Austin Wagon Loader, The.....(Jan.) 39

Backwater Curves in Sewer Design, Computation of, by C. D. Hill.....164
Bind Your Copies of M. & C. E., E....233
Bitoslag on Old Foundations, Detours Unnecessary While Laying 174
Bituminous Concrete Pavements, New Developments in Construction of, by Theodor S. Oxholm.....150
Bituminous Macadam, Repairing With Coal Patching Material in Philadelphia, by Wm. C. Bailey..... 57
Bituminous Macadam Roadways, Procedure in the Construction of, by J. E. Pennybacker 101
Bituminous Pavements of Fine Aggregate, Design of, by R. Keith Compton 234
Bituminous Surface Treatment of Broken Stone Roads, by Wm. W. Cox 170
Blasting, Removing a Concrete Bridge by 44
Boiler Scale, How to Avoid.....258
Boom and Bucket, Smith Distributing ..... (Apr.) 40
Bond Issues, Motor Fees as a Basis for Highway Construction, by S. E. Bradt 99
Bond Campaigns for Municipal Improvements, How to Conduct, by Robert E. McDonnell 36
Brick Pavement Connecting Waterloo and Cedar Falls, Iowa, Construction and Inspection Methods Employed in Building, by E. A. Zack and C. M. Fischer 195
Brick Pavement Construction in the City of Chicago, Recent Experience in the Development of, by H. J. Fixmer...147
Brick Pavements, Construction of, In and Near Danville, Illinois, by Harlan H. Edwards 3
Brick Pavements, Standard Specifications for, by Maurice B. Greenough.. 57
Bridge, Concrete, Removing by Blasting 44
Bridge Plans in Indiana, Approval of Highway, by Wm. J. Titus.....173
Bridges, Widths and Loadings for Highway, by Lewis M. Gram.....204
Broken Stone Roads, Bituminous Surface Treatment of, by Wm. W. Cox..170
Bucket Elevator for Cleaning Sedimentation Chamber, San Francisco Sewer Department Designs .....(June) 39
Building Zone Ordinance of Portland, Oregon, The New, by Charles H. Cheney 198
Buncombe County, North Carolina, The Modern Highway System of, by N. Buckner 196
Bureau of Public Roads, New Highway Tests Being Made by the.....160

Car Tracks, Effect of, Upon Traffic Capacity of Roadways, by Geo. W. Tillson 69
Cement Sacks at Work, Keep The.....216
Centrifugal Pumps for 900-ft. Head, by Farley Gannett and Jacob L. Crane, Jr. 249
Centrifugal Pumps, High Efficiency....189
Centrifugal Pumps in Municipal Water Plants, The Use of, by Russell A. Murdoch 253
Charging Bins and Pebble Washing Plant Saves Money on Concrete Road Construction, Use of .....(Feb.) 33
Chicago, Recent Experience in the Development of Brick Pavement Construction in the City of, by H. J. Fixmer 147
Chlorination and Screened Sewage..... 92
Chlorination Would Have Prevented Sickness and Death, Where, E. 145
Chlorine Purifies Poland's Polluted Streams 138
City Planning in St. Paul, Minn.....174
Cleaning Sedimentation Chamber, San Francisco Sewer Department Designs Bucket Elevator for.....(June) 39
Cleaning Water Mains in St. Louis, Mo., by Edward E. Wall.....249
Cold Patching Material, Repairing Bituminous Macadam With, in Philadelphia, by Wm. C. Bailey..... 57
Columbus, Ohio, Grit Chambers on Combined Sewers at, by W. J. Weaver..149
Combination Dragline Machine, Austin, The .....(Feb.) 34
Computation of Backwater Curves in Sewer Design, by C. D. Hill.....164
Concrete Bridge, Removing by Blasting 44
Concrete Floor in An Old Building, New, The Small Engineering Job, by E. McCulloh 16
Concrete in Water Works Construction. 92
Concrete Pavement Construction in Lakewood, Ohio, Some Details of, by E. A. Fisher 107
Concrete Pavement Design, Fundamental Considerations Affecting, by S. T. Morse 62
Concrete Pavement Design, Fundamental Considerations Affecting, by S. T. Morse 154
Concrete Road Construction, Use of Charging Bins and Pebble Washing Plant Saves Money on.....(Feb.) 33
Concrete Roads in Nebraska, Constructing .....(Apr.) 33
Concrete Road Jobs in Illinois, List of Construction Equipment Used on Fifteen ..... (Apr.) 34
Concrete Road Machinery and Labor Substitutes; Some of the 1919 Developments, by H. W. Eldridge..... ..... (Jan.) 33
Conservation and Water Power, by H. de B. Parsons.....244
Conserving Poles and Posts..... 80
Construction and Inspection Methods in Building the County Brick Pavement Connecting Waterloo and Cedar Falls, Iowa, by E. A. Zack and C. M. Fischer 195
Construction Equipment Used on Fifteen Concrete Roads in Illinois, List of .....(Apr.) 34
Construction Jobs, Choosing the Pump and the Size of Pipe on, by R. E. S. Geare .....(June) 36
Construction of a Nebraska Concrete Road, Use of Equipment Cuts Cost on .....(Jan.) 40
Construction of Brick Pavements, The, In and Near Danville, Illinois, by Harlan H. Edwards 3
Contracting Business, A Movement to Decrease the Hazards in.....(June) 33
Construction, The Triangle, E. 50
Contractor and Frequent Inconsistencies Met With in Specifications, The Municipal, by Wm. C. Fraser.....120
Contractor, Co-Operation Between the Engineer and, by C. D. Franks.....206
Contractors and Road Builders, Book on Pumping for .....(June) 38
Contractors in Wyoming, Co-Operation with Highway 100
Contractors, Proper Co-Operative Relations Between Highway Engineers and, by H. S. Mattimore.....123
Conveyors, Scoop, Storing Coal or Similar Material by Means of 42
Co-Operation Between the Engineer and Contractor, by C. D. Franks.....206
Co-Operation in the Highway Field, E... 50
Co-Operation, Not Competition, Between Engineering Societies, Let Us Have, E. 49
Co-Operation with Highway Contractors in Wyoming 100
County Highway Service, Proposed Schedule of Salaries for Engineers in. 56
Crest Dams, Movable, Design and Operation of, by Wm. G. Fargo.....157
Culverts, Ready Built or Lumber Frames for .....(Apr.) 38

Dams, Design and Operation of Movable Crest, by Wm. G. Fargo.....157
Design and Cost of Water Supply Dams at Jacksonville and Decatur, Ill., by Samuel A. Greeley 88
Design and Operation of Movable Crest Dams, by Wm. G. Fargo.....157
Design, Concrete Pavement, Fundamental Considerations Affecting, by S. T. Morse 62
Design of Bituminous Pavements of Fine Aggregate, by R. Keith Compton...234
Designing Street Pavements for Small Minnesota Cities, by Geo. M. Shepard 167
Design of Modern Road Surfaces, With Especial Reference to Alignment, Grade, Width and Thickness, by Charles M. Upham 12
Design of New Sewage Treatment Works at Fort Sheridan (Ill.) General Hospital No. 28, by H. R. Abbott 212
Design of Pavement Surfaces for Modern Traffic, The, by H. J. Fixmer.... 67
Design of Small Water Works, Considerations Affecting the, by J. Q. Wickham 228
Detours for Highway Construction, Efficient, by L. H. Nellsen.....161
Detours Unnecessary While Laying Bitoslag on Old Foundations.....174

Detroit Street Railway Bond Election, Using Motion Pictures in the.....268
Dictated Article, The, E. 50
Dragline Machine, The Austin Combination .....(Feb.) 34

Educator, A Living Wage for the Engineering, E. 194
Electrically Operated Water Works Pumping Plants in Indiana, by G. C. Blalock 83
Employment Agencies, Using, E. 98
Engineer and Contractor, Co-Operation Between, by C. D. Franks 206
Engineer in Politics, An, E. 194
Engineers in State Highway Service, Proposed Schedule of Salaries for, by A. N. Johnson 9
Engineer, The Military, E. 146
Engineering As a Career, Highway, by A. N. Johnson.....111
Engineering Educator, A Living Wage for the, E. 194
Engineering Expense, Double, E. 98
Engineering Features of a Golf Club, The, by Paul E. Green.....136
Engineering Job, The Small, E. 1
Engineering Societies, Let Us Have Co-Operation, Not Competition, Between, E. 49
Engineering Standards, Arbitrary, E... 97
Estimating Labor Heur Requiremcnts for Three Types of Street Railway Track Construction, by D. B. Davis..239
Equipment, Use of, Cuts Cost on Construction of a Nebraska Concrete Road .....(Jan.) 40
Equipment Used on Fifteen Concrete Roads Jobs in Illinois, List of Construction .....(Apr.) 34
Evansville, Ind., Water System, Results of Pitometer Survey of the, by Charles Streithof 186
Excavator and Loader, Two Men Do Work of Fifteen With New.....(May) 38
Excavators, Modern Uses of Trench, by J. McElroy .....(Feb.) 40
Expense, Double Engineering, E. 98
Explosives on Road Grading, Use of, by M. C. Petter..... 19

Fire Protection, Township, E.....193
Fort Sheridan, (Ill.) General Hospital No. 28, Design of New Sewage Treatment Works at, by H. R. Abbett....212
Frames for Culverts, Ready Built or Lumber .....(Apr.) 38

Garbage Disposal and the Economic Recovery of Valuable Constituents of Municipal Waste, by Samuel A. Greeley. 22
Gas Plant at Omaha, Neb., Municipal Ownership of 189
Golf Club, Engineering Features of the, by Paul E. Green.....136
Good Article, When a Man Writes, E..233
Good-Will Advertising in Water Works Business, Example of.....129..
Grading Earth Roads in Nebraska, ... (Apr.) 40
Grit Chambers on Combined Sewers at Columbus, Ohio, by W. J. Weaver....149
Gravel Pits, Cities and Counties Should Adopt Methods Successfully Employed by Commercial Producers in Opening Up .....(May) 33
Gravel Roads in Wilson County, Kansas, Method and Cost of Construoting, by M. W. Watson.....210
Gravel Specifications, Relation of, to Production, by R. C. Yeoman.....172
Group Life Insurance, Albuquerque, New Mexico Covers All Municipal Employes with 216
Gypsum Roof Decks for Hydro-Electric Buildings, by Curtis F. Columbia....132

Hamilton, Ohio, Building Storm Water Sewers in, by Roger B. McWherter... 52
Hazards in the Contracting Business, A Movement to Decrease.....(Junc) 33
Highways, Attractive, E..... 1
Highway Bridge Plans in Indiana, Approval of, by Wm. J. Titus.....173
Highway Bridges, Widths and Loadings for, by Lewis M. Gram.....204
Highway Construction Bond Issues, Motor Fees as a Basis for, by S. E. Bradt 99
Highway Construction, Development and Inspection of Supplies of Material for, by Austin B. Fletcher..... 29
Highway Construction, Efficient Detours for, by L. H. Neilsen.....161
Highway Construction, the Development and Use of Mechanical Equipment In, by K. H. Talbot.....(Mch.) 33
Highway Construction, Use of Labor-Saving Devices on, by Richard Hopkins. 118
Highway Contractors in Wyoming, Co-Operation with 100
Highway Engineers and Contractors, Proper Co-Operative Relations Between, by H. S. Mattimore.....123
Highway Engineering as a Career, by A. N. Johnson.....111
Highway Field, Co-Operation in the, E 50
Highways, Some Economic Questions Affecting, by J. E. Pennybacker..... 8
Highway System of Buncombe County, North Carolina, The Modern, by N. Buckner 196
Highway Tests Being Made by the Bureau of Public Roads, New, by A. T. Goldbeck 160
Highway Work in Missouri, Features of, by Alexander W. Graham..... 78
Highway Work in New England in 1920 52
Housing—The Engineer's Job, by Louis L. Tribus 103
Hydro-Electric Buildings, Gypsum Roof Decks for, by Curtis F. Columbia....132

Illinois Villages Still Unsewered, Many Prosperous. 151
Imhoff Sewage Tanks, Operating Experiences with, by W. G. Kirchoffer..107
Impact Tests on Roads, by C. C. Wiley. 75
Improving Sewage Plant Operation, by C. H. Currie 61
Inland Waterways, The Reviving Interest in, by W. J. Sherman.....237
Iron and Sulphur From Ground Water in Ohio, Removal of, by George Champe 266

Jet Condensers, Wheeler, An Important Improvement in 140
Jointed Blade Road Maintainers, Desirable Features in.....(Feb.) 38

Keeping Up Versus Catching Up, E.... 49

Labor-Saving Devices on Highway Construction, Uses of, by Richard Hopkins 118
Labor Substitutes and Concrete Road Machinery; Some of the 1919 Developments, by H. W. Eldridge.....(Jan.) 33
Lakewood, Ohio, Some Details of Concrete Pavement Construction in.....107
Leakage in Small Water Works System Amount of, by Lawrence W. Cox....252
Life Insurance, Albuquerque, New Mexico, Covers All Municipal Employees With Group 216
Lighting System at a Reduced Expense, Street, How to Secure a Better, by Frank Koester 201
Livingston, Mont., Competition Between Municipally and Privately Owned Water Works at, by Robert E. McDonnell. 219
Loader, Wagon, The Austin.....(Jan.) 39
Loadings for Highway Bridges, by Lewis M. Gram 204
Loader, Two Men Do Work of Fifteen with New Excavator and.....(May) 38

Macadam and Gravel, Surface Treatments on, by Philip P. Sharples.....115
Macadam Roads, Maintenance of. by L. G. Quigley 207
Macadam Roller Design, New....(Feb.) 38
Maintenance of Macadam Roads, by L. G. Quigley 207
Material for Highway Construction, Development and Inspection of Supplies of, by Austin B. Fletcher..... 29
Mechanical Equipment in Highway Construction, The Development and Use of, by K. H. Talbot.....(Mch.) 33
Memoirs of Ex-Service Men, Professional, E. 2
Meter Reading, Piece-Work System in, The, by J. A. A. Beaudin..... 40
Method and Cost of Constructing Gravel Roads in Wilson County, Kansas, by M. W. Watson.....210
Method of Developing A Shallow Ground Water Supply, Rational, by W. D. P. Warren. 220
Method of Handling Mixed Aggregate to Paving Mixer, Short Cut.....(Apr.) 38
Methods Successfully Employed by Commercial Producers in Opening Up Gravel Pits, Cities and Counties Should Adopt .....(May) 33
Military Engineer, The, E.....146
Missouri, Features of Highway Work in, by Alexander W. Graham..... 78
Mixer, Paving, Features of the Smith Simplex ..... (Jan.) 40
Motion Pictures in the Detroit Street Railway Bond Election, Using.....268
Money to Public Utilities, The Present High Cost of, by Dow R. Gwinn.....152
Motor Fees as a Basis for Highway Construction Bond Issues, by S. E. Bradt. 99
Motor Trucks and Our Pavements, by Monroe L. Patzig.....161
Motor Truck Traffic, Constructing Roads for, by T. R. Agg.....112
Municipal Improvements, How to Conduct Bond Campaigns for, by Robert E. McDonnell 36
Municipal Ownership of Gas Plant at Omaha, Neb. 189
Municipal Waste, Garbage Disposal and the Economic Recovery of Valuable Constitutents of, by Samuel A. Greeley. 22

Nebraska, Constructing Concrete Roads in. .....(Apr.) 33
Nebraska, Grading Earth Roads in ..... (Apr.) 40
Nebraska, The Road-Making Materials of, by A. S. Mirick.....208
New England, Highway Work in 1920 in 52
New Jersey, Asphalt Roads in.....248
New York Barge Canal, Unique Reservoir Dams on.....130
Norfolk, Va., Water Supply Shortage at. 90

Obligations Are Reciprocal, E.....145
Oklahoma City, Reconstruction of 20-Year-Old Asphaltic Pavements in...248
Operation of Sewage Treatment Plants, Rules for, by H. R. Abbott.....134
Our Greatest Gain from the War, E.... 2

Panama Canal Zone, The Construction of Asphaltic Roads in..... 11
Paved Highway, The Proper Width of A Permanently, by Monroe L. Patzig. 66
Pavement Construction in the City of Chicago, Recent Experience in the Development of Brick, by H. J. Fixmer 147
Pavement Construction in Lakewood, Ohio, Concrete, Some Details of, by E. A. Fisher.....107
Pavement Connecting Waterloo and Cedar Falls, Iowa, Brick, Construction and Inspection Methods Employed in Building the County, by E. A. Zack and C. M. Fischer.....195
Pavement Design, Concrete, Fundamental Considerations Affecting, by S. T. Morse 62
Pavement Surfaces for Modern Traffic, The Design of, by H. J. Fixmer..... 67
Pavements and Roads and Some New Discoveries in Pavement Construction, History of Warrenite-Bitulithic, by Geo. C. Warren.....242
Pavements, Brick, Construction of, In and Near Danville, Illinois, by Harlan H. Edwards 3
Pavements, Brick, Standard Specifications for, by Maurice B. Greenough.. 57
Pavements for Small Minnesota Cities, Designing Street, by Geo. M. Shepard.167
Pavements, Motor Trucks and Our, by Monroe L. Patzig.....161
Pavements, New Developments in Construction of Bituminous Concrete, by Theodor S. Oxholm.....150
Paving Mixer, Features of the Smith Simplex ..... (Jan.) 40
Paving Mixer, Short Cut Method of Handling Mixed Aggregate to (Apr.) 38
Payment for Preparing the Subgrade; How Rochester, N. Y., Solved the Problem, by J. O. Preston..... 26
Pavements in Oklahoma City, Reconstruction of 20-Year-old Asphaltic...248
Pavements of Fine Aggregate, Design of Bituminous, by R. Keith Compton...234
Payments on Road Construction Contracts, Making, by C. Coykendall.....100
Pavements, Specifications for Sheet Asphalt and Asphaltic Concrete, Asphalt Cement Qualities and Tests Needed in, by J. W. Howard.....236
Piece-Work System in Meter Reading, The, by J. A. A. Beaudin..... 40
Pipe on Construction Jobs, Choosing Pump and Size of, by R. E. S. Geare .....(June) 36
Pitometer Survey of the Evansville, Ind., Water System, Results of, by Charles Streithof 186
Plant Operation, Guiding Principles in Water Purification, by W. H. Dittoe..130
Planning, Lot and Block, in Residential Districts, by Arthur C. Comey..... 30
Plant Operation, Sewage, Improving, by C. H. Currie 61
Poland's Polluted Streams, Chlorine Purifies. 138
Politics, An Engineer in, E.....194
Polluted Streams, Chlorine Purifies.....138
Portable Air Compressor for the Contractor, A..... (May) 40

Portable Sand and Gravel Washer, A New ..... (June) 38
Portland, Oregon, The New Building Zone Ordinance of, by Charles H. Cheney 198
Production, Relation of Gravel Specifications to, by R. C. Yeoman.....172
Professional Memoirs of Ex-Service Men, E. 2
Public Utilities, Present High Cost of Money to, by Dow R. Gwinn.....152
Pump and the Size of Pipe on Construction Jobs, Choosing the Type of, by R. E. S. Geare.....(June) 36
Pumping, Book on, for Contractors and Road Builders .....(June) 38
Pumping Plants in Indiana, Water Works, Electrically Operated, by G. C. Blalock 83
Pumps, Centrifugal, in Municipal Water Plants, the Use of, by Russell A. Murdoch 253
Pumps, Centrifugal, for 900-ft. Head, by Farley Gannett and Jacob L. Crane, Jr. 249
Pumping Stations, Steam Power Plants, for, by P. J. Kiefer.....227
Purification Plant and Water Supply, Twin Falls, Idaho, by Robert E. McDonnell. 81
Pumps, Experiences with Air Lift, by W. G. Kirchoffer.....177
Pumps, High Efficiency Centrifugal....189

Quality of Road Stone, Service the Final Test of, By H. Eltinge Breed..... 51

Rebuilding of Water Works, Some Problems Encountered in the, by Charles Brossman. 217
Reconstruction of 20-Year-Old Asphaltic Pavements in Oklahoma City.....248
Refuse Disposal and Snow Removal in Buffalo, N. Y., Street Cleaning, by George H. Norton..... 21
Repairing Bituminous Macadam With Cold Patching Material in Philadelphia, by Wm. C. Bailey..... 57
Reservoir Dams on New York Barge Canal, Unique 130
Residential Districts, Lot and Block Planning In, by Arthur C. Comey.... 30
Roads and Pavements and Some New Discoveries in Pavement Construction, History of Warrenite-Bitulithic, by Geo. C. Warren.....242
Road and Street Work, Using The Steam Shovel in .....(May) 36
Road Builders and Contractors, Book on Pumping for .....(June) 38
Road Construction, Concrete, Use of Charging Bins and Pebble Washing Plant Saves Money on.....(Feb.) 33
Road Construction Contracts, Making Payments on, by C. Coykendall.....100
Road Grading, Use of Explosives on, by M. C. Potter..... 19
Road Jobs in Illinois, List of Construction Equipment Used on, Fifteen Concrete .....(Apr.) 34
Road Machinery, Concrete, and Labor Substitutes; Some of the 1919 Developments, by H. W. Eldridge....(Jan.) 33
Road Maintainers, Desirable Features in Jointed Blade .....(Feb.) 38
Road-Making Materials of Nebraska, The, by A. S. Mirick.....208
Road, Nebraska Concrete, Use of Equipment Cuts Cost on Construction of a ..... (Jan.) 40
Road Stone, Service the Final Test of Quality of, by H. Eltinge Breed..... 51
Road Surfaces, With Especial Reference to Alignment, Grade, Width and Thickness, The Design of, by Charles M. Upham 12
Road, Asphaltic, The Construction of in The Panama Canal Zone..... 11
Roads, Bituminous Surface Treatment of Broken Stone, by Wm. W. Cox.....170
Roads for Motor Truck Traffic, Constructing, by T. R. Agg.....112
Roads, Impact Tests on, by C. C. Wiley. 75
Roads in Nebraska, Constructing Concrete .....(Apr.) 33
Roads in Nebraska, Grading Earth ..... (Apr.) 40
Roads in New Jersey, Asphalt.....248
Roads in Wilson County, Kansas, Method and Cost of Constructing, by M. W. Watson 210
Roads, Maintenance of Macadam, by L. G. Quigley 207
Roadways, Bituminous Macadam, Procedure in the Construction of, by J. E. Pennybacker 101
Roadways, Effect of Car Tracks Upon Traffic Capacity of, by Geo. W. Tillson 69
Roadways, Procedure in the Construction of Bituminous Macadam, by J. E. Pennybacker 101
Roller Design, Macadam New...(Feb.) 38
Roof Decks, Gypsum, for Hydro-Electric Buildings, by Curtis F. Columbia.....132
Rules for Operation of Sewage Treatment Plants, by H. R. Abbott.....134

St. Paul, Minn., City Planning in.....174
Salaries for Engineers in County Highway Service, Proposed Schedule of... 56
Salaries for Engineers in State Highway Service, Proposed Schedule of, by A. N. Johnson..... 9
Sand and Gravel Washer, Portable, A New ..... (June) 38
San Francisco Sewer Department Designs Bucket Elevator for Cleaning Sedimentation Chamber..... (June) 39
Schedule of Salaries for Engineers in County Highway Service, Proposed... 56
Schedule of Salaries Proposed for Engineers in State Highway Service, by A. N. Johnson..... 9
Scoop Conveyors, Storing Coal or Similar Material by Means of..... 42
Sedimentation Chamber, San Francisco Sewer Department Designs Bucket Elevator for Cleaning.....(June) 39
Self-Heating Asphalt Smoothing Iron, A. 125
Service, the Final Test of Quality of Road Stone, by H. Eltinge Breed..... 51
Sewage Disposal in Small Cities and Towns, by Milton F. Stein..... 71
Sewage, Chlorination of Screened..... 92
Sewage Plant Operation, Improving, by C. H. Currie..... 61
Sewage Tanks, Operating Experiences with Imhoff, by W. G. Kitchoffer....107
Sewage Treatment Plant at West Falls, Virginia, New Institutional, by George L. Robinson 156
Sewage Treatment Plants, Rules for Operation of, by H. R. Abbott.....134
Sewage Treatment Works at Fort Sheridan (Ill.) General Hospital No. 28, Design of New, by H. R. Abbott.....212
Sewerage and Water Systems, Need for Comprehensive, by John F. Druar...264
Sewers at Columbus, Ohio, Grit Chambers on, by W. J. Weaver.....149
Sewer Design, Computation of Backwater Curves in, by C. D. Hill.....164
Sewers, Storm Water, Building in Hamilton, Ohio, by Roger B. McWhorter.. 52
Shallow Ground Water Supply, Rational Method of Developing A, by W. D. P. Warren 220
Small Agricultural Villages, Water Works Requirements for, by Edgar A. Rossiter 226
Small Engineering Job, The E..... 1
Small Engineering Job—A New Concrete Floor In An Old Building, The, by E. McCulloh..... 16
Small Water Works, Considerations Affecting the Design of, by J. Q. Wickham. 228
Smith Distributing Boom and Bucket ..... (Apr.) 40
Smith Simplex Paving Mixer, Features of the .....(Jan.) 40
Smoothing Iron, A Self-Heating Asphalt. 125
Snow Removal in Buffalo, N. Y., Refuse Disposal and Street Cleaning, by George H. Norton 21
Societies, Engineering, Let Us Have Co-Operation, Not Competition, Between, E. 49
Specifications for Brick Pavements, Standard, by Maurice B. Greenough 57
Specifications for Sheet Asphalt and Asphaltic Concrete Pavements, Asphalt Cement Qualities and Tests Needed in, by J. W. Howard.....236
Specifications, The Municipal Contractor and Frequent Inconsistencies Met With In, by Wm. C. Fraser.....120
Specifications to Production, Relation of Gravel, by R. C. Yeoman.....172
Steam Power Plants for Pumping Stations, by P. J. Kiefer.....227
Steam Shovel In Road and Street Work, Using the .....(May) 36
St. Louis, Mo., Water Main Cleaning In, by Edward E. Wall.....249
Storing Coal or Similar Material by Means of Scoop Conveyors..... 42
Storm Water Sewers in Hamilton, Ohio, Building, by Roger B. McWhorter.... 52
Straight Thinking, in The Interest of, E. 193
Street Cleaning, Refuse Disposal and Snow Removal in Buffalo, N. Y., by George H. Norton 21
Street Lighting System at a Reduced Expense, How to Secure a Better, by Frank Koester 201
Street Railway Track Construction, Estimating Labor Hour Requirements for Three Types of, by D. B. Davis..239
Subgrade, Payment for Preparing the; How Rochester, N. Y. Solved the Problem, by J. O. Preston..... 26
Sulphur and Iron from Ground Water in Ohio, Removal of, by George Champe 266
Surface Treatments on Macadam and Gravel, by Philip P. Sharples.....115

Terms Used in Connection with Asphalt for Highway Work..... 19
Tests Being Made by the Bureau of Public Roads, New Highway, by A. T. Goldbeck 160
Tests on Roads, Impact, by C. C. Wiley. 75
Thinking, In the Interest of Straight, E.193
Township Fire Protection, E.....195
Track Construction, Street Railway, Estimating Labor Hour Requirements for Three Types of, by D. B. Davis..239
Traffic Capacity of Roadways, Effect of Car Tracks Upon, by Geo. W. Tillson. 69
Triangle, The Construction, E..... 50
Trench Excavators, Modern Uses of, by J. McElroy .....(Feb.) 40
Twin Falls, Idaho, Water Supply and Purification Plant, by Robert E. McDonnell. 81

Unloading Asphalt and Road Oil from Tank Cars 126

Wage for the Engineering Educator, A Living, E. 194
Wagon Loader, The Austin.....(Jan.) 39
War, Our Greatest Gain From The, E.. 2
Warrenite-Bitulithic Roads and Pavements and Some New Discoveries in Pavement Construction, History of, by Geo. C. Warren.....242
Water and Sewerage Systems, Need for Comprehensive, by John F. Druar...264
Water in Ohio, Ground, Removal of Sulphur and Iron From, by George Champe 266
Water Main Cleaning in St. Louis, Mo., by Edward E. Wall.....249
Water Plants, Municipal, The Use of Centrifugal Pumps in, by Russell A. Murdoch 253
Water Power and Conservation, by H. de B. Parsons.....244
Water Purification Plant Operation, Guiding Principles in, by W. H. Dittoe.130
Water Supply and Purification Plant, Twin Falls, Idaho, by Robert E. McDonnell. 81
Water Supply Shortage at Norfolk, Va.. 90
Water Supply Dams at Jacksonville and Decatur, Ill., Design and Cost of, by Samuel A. Greeley..... 88
Water Supply, Ground, Rational Method of Developing A Shallow, by W. D. P. Warren 220
Water System, Results of Pitometer Survey of the, Evansville, Ind., by Charles Streithof.....186
Waterways, The Reviving Interest in Inland, by W. J. Sherman.....237
Water Works at Livingston, Mont., Competition Between Municipally and Privately Owned, by Robert E. McDonnell 219
Water Works Business, Example of Good-Will Advertising in.....129
Water Works, Considerations Affecting the Design of Small, by J. Q. Wickham. 228
Water Works Construction, Concrete in. 92
Water Works in 1865 and in 1920, by John W. Hill..... 33
Water Works Issue, E.....233
Water Works, Prewar and Present Reproduction Costs of, by L. R. Howson.184
Water Works Pumping Plants in Indiana, by G. C. Blalock..... 83
Water Works Requirements for Small Agricultural Villages, by Edgar A. Rossiter 226
Water Works, Some Problems Encountered in the Rebuilding of, by Charles Brossman 217
Water Works Systems, Amount of Leakage in Small, by Laurence W. Cox....252
Well Contract, Artesian, Experiences in, by Jerry Donohue.....260
West Falls, Virginia, New Institutional Sewage Treatment Plant at, by George L. Robinson 156
Wheeler Jet Condensers, An Important Improvement in 140
Who Knows? E. 97
Widths and Loadings for Highway Bridges, by Lewis M. Gram 204
Width of a Permanently Paved Highway, The Proper, by Monroe L. Patzig 66

Zone Ordinance of Portland, Oregon, The New Building, by Charles H. Cheney 193
Zoning A Municipality, The Importance of, by Louis Bartlett.....163

EDITORIALS

ATTRACTIVE HIGHWAYS

It is estimated by some authorities that appropriations of funds for the construction of hard surface roads in the United States in 1920 will reach a total of one billion dollars. This is five times greater than the previous maximum yearly expenditure. Now that the era of greatest activity in road building has come let us give proper consideration to the beautification of improved highways.

There has been too much cutting and slashing, too much clearing and grubbing in connection with highway construction. The natural beauty of the highway should be safeguarded. Many road builders have sanctioned the wanton destruction of bushes and small trees at the roadside. Let us take care that in improving a roadway we do not transform a beautiful drive into a barren highway. As one observer says: "This change from the beautiful to the ugly has not been called for and should not have been permitted." It is recommended that each state highway commission employ a landscape architect to supervise the conservation of the natural beauty of the highway and to plan for the embellishment of unattractive roadsides. Every individual should do his share in this work of beautification.

"David Grayson" and others have written of the lure of the "friendly road." Many "adventures in contentment" are experienced by travelers on the highways. The highway is as old as the race and the urge to travel on it is an even deeper-rooted instinct in man than his desire to live in a house. The railroad is a modern and noisy device that restricts the freedom of movement and soon wearies the traveler. Travel by water is often necessary but usually unpleasant. Travel by air is still a defiance of death and but little more. Not only is the air traveler supremely uncomfortable but he is deafened by the roar of his motor. He gets but an inverted and distorted view of the earth. Air travel may be successfully commercialized but it can never provide much pleasure to man who by nature is a groundling. But travel on a pleasant highway renews youth and restores the soul.

Wherein lies the pleasure of motoring over a good country road? It is not merely in the motion for that is more easily experienced on the city boulevards. It is not in the droning of the motor except to the occasional driver who is interested only in the operation of a piece of mechanism. The real pleasure in highway travel comes from looking at the swiftly changing beauty of the landscape. Where such beauty is absent there is no joy in highway travel and one takes the shortest cut back to town.

Let us make and keep our highways attractive.

THE SMALL ENGINEERING JOB

A contributor to this issue comments on the fact that early in his career as an engineer, with the wealth of descriptive matter available, it would have been easy for him to surpass such works as the Sweetwater Dam or the Croton Aqueduct; but when it came to designing or detailing the every-day, average structure of moderate cost, especially with the inadequate funds generally available, in all the realm of engineering literature he found scarcely a word for his guidance.

In over twenty years of practice he has learned that the majority of engineering problems are not of great dramatic interest, but that there is much good engineering done in achieving success in modest undertakings with insufficient funds.

The contributor states that within the past five or six years there has been a marked change in the character of matter published in engineering journals and that today such journals contain much matter of interest to the average engineer.

While it is gratifying to learn that a careful observer has noted such a distinct improvement in technical journalism we feel there is yet much room for improvement and in the same direction. We believe practically all the editors of engineering journals, with possibly one exception, would gladly make their papers of more interest and value to the average engineer if they could.

For a long time the fault rested with the editors who filled their journals with descriptions of work of such exceptional magnitude that they not only failed to help the average practitioner of engineering but gave him an undeserved feeling of insignificance. Now the fault rests with the average engineer who feels that his work is of interest to none but himself and he cannot be hired, coaxed, wheedled or cajoled into writing anything whatever about it for publication. Many engineers insist that their work is so commonplace that a description of it would only invite ridicule.

If engineers, as a class, ever become willing to write about their handling of interesting and important, though small, pieces of engineering work for the benefit of other engineers, they will find the engineering paper editors very quick and very willing to co-operate in the dissemination of such information. We are speaking now in constructive and friendly criticism of

engineers as a class. That many individual engineers do write of their work is obvious from the fact that engineering societies and engineering journals keep on functioning. These exceptional men make the journals and the societies possible and worth while. If all engineers would regard it as a professional duty to tell of their work the engineering papers would be much more interesting and useful than they are now. They would not cost more but they would be worth more.

We are constantly seeking articles pertaining to

OUR GREATEST GAIN FROM THE WAR

The cost of the great war to the United States was considerable in men and enormous in money if we consider the great war debts as so much money lost. But to regard these debts as money lost is an economic fallacy when viewed broadly for one man's loss was the gain of another. There was a great shifting of credits but the actual destruction of our wealth was not great.

When we consider our gains from the war we find these far outweighing the losses. The moral leadership of the world is undoubtedly ours, though temporarily clouded, perhaps, by the prolonged deadlock on the ratification of the peace treaty with its league of nations covenant. Those who lightly dismiss this moral leadership of the world as a matter of but idealistic or academic interest should not fail to consider also its intense practicality. It amounts to nothing less than a firm grip on the good will of the world and the value of good will in business dealings between nations is of the same quality that governs the transaction of business between individuals. That the highly idealistic and moral sides of our leadership during the war were exceeded only by its intensely practical side is a fact much better appreciated by the average European than by the average American. We have an overall check on the truth of this statement in the fact that we were a debtor nation at the outbreak of the war and we are now the greatest creditor nation.

The changes in our economic relationship to the rest of the world are all in our favor. Materialists have little to complain of in this respect if they can disabuse their minds of political prejudices and consider results rather than the methods employed in getting the results.

But the great improvement in our relative position in the economic world is not our greatest gain from the war. There is another and a greater gain, one more closely touching the daily lives of all of us. That gain is the secure confidence of the American business man in the United States as a tremendously fortunate, rich and independent going concern.

Before the war it was distressing to observe the timidity in business of both big and little business men. Every time stocks went off a point the big fellows began to grow frightened. A drop of two points produced a near panic, while a drop of five points was the signal for a rush of the big fellows to the cyclone cellar. The little fellows, with their teeth chattering from fright, were only one jump behind. That was indeed a sad spectacle and one we were often forced to look at. Since the war we have learned that the end of the world does not come easily; that the economic structure can assimilate a vast amount of punishment. The stock market is not as flighty as it was, which is an important gain from the war, and the people pay less attention to the stock quotations than they did before the war, which is an even greater gain.

So we conclude that our greatest gain from the war is our liberation from the fetters of fear that once bound us. We are all energetically transacting business, unmindful of the fact that as a nation we have accumulated a tidy debt. We are paying very high prices for everything, magazines possibly excepted, and while we don't know where we are going we are having a perfectly good time on the way.

We have reached another presidential year; a windy year with incessant gas attacks. Yet the people are largely unperturbed, realizing, somewhat vaguely perhaps, that the country will be saved again this fall and every four years thereafter as long as we have tremendous natural resources still undeveloped.

It is this indifference to daily disturbances to business of one sort or another, on the part of the American people, that constitutes our greatest gain from the war. This generation has learned to go blithely about its business, to be "up and doing, with a heart for any fate."

PROFESSIONAL MEMOIRS OF EX-SERVICE MEN

A year ago it was to be expected that professional men released from military duties would enrich the literatures of their several professions with accounts of their activities during the war. Such accounts still possessed some news value a year ago and some interest, despite the keen desire of most engineers to forget the war as soon as possible.

But we are dismayed to find that the flood of these professional memoirs is not receding very fast. Examination of the programs of engineering society conventions being held this winter reveals many examples of these throwbacks to scientific barbarism.

We beg leave to suggest to the various colonels, majors, captains, etc., that if they have pent-up, scientific, war stories bumping against their brows that these be released for publication through the periodical called Professional Memoirs which, as we understand it, is the proper repository for such literature, made and provided by the engineer corps of the United States Army. In that place such writings are always in season. If published there they will reach the greatest number of interested readers and will be preserved to future generations of warriors and, we freely concede, may be of immense value later on.

The Construction of Brick Pavements In and Near Danville, Illinois

By Harlan H. Edwards, City Engineer, Danville, Ill.

Danville, Illinois, a city of about 40,000 population, and one of the homes of the paving brick industry, has probably as many brick surfaced streets of various types and ages as may be found in the middle west. Starting from the paving of a few main streets in 1890, the mileage of brick paved streets has rapidly increased to a total of 45 miles which is about 98 per cent. of the total paved mileage in the city. In this mileage about every type of brick pavement in existence has been constructed. Starting from the original type of two course brick pavement or one course brick on a gravel or stone foundation, the types run through brick laid on natural cement concrete base or Portland cement concrete base with sand cushion and sand filler to the higher types of filler—asphalt, pitchmastic, and cement. Many lessons have been learned from these pavements and the design of many streets have been benefited thereby. The work just completed and work now under way for construction in 1920 have shown the result of careful thought and investigation concerning the price of materials, character of sub-soil, and density of traffic to be expected on these streets. On one street several thousand dollars were saved by utilizing an existing old brick base, while on another street money was saved by reducing the thickness of brick required. Many other like savings will be made during the coming year to offset the additional cost of paving caused by high labor costs and freight rates. In order to understand some of the reasons for the changes which have been made in the past two or three years in brick pavement construction, it is necessary that a brief resume be made of the development of the brick pavement.

FOUR INCHES OF BRICK ON A ONE INCH CONCRETE BASE.

Development of the Brick Pavement

The earliest brick roads were constructed with what is now considered common building brick, placed on tarred boards on compacted earth or gravel, and covered with a layer of sand to smooth over inequalities of the surface. The interstices between the bricks or the "joints" were filled with sand, and the road opened to traffic immediately. This surface was better than dirt, especially in wet weather, but since there was little or almost no base to distribute and carry the load these pavements were suited principally for light traffic. In order, therefore, to provide a better foundation, a layer of brick was placed flatwise on the earth and gravel, a layer of sand or fine gravel on top of this, and upon this bed the wearing surface or brick was laid on edge. This type of surface made a more nearly water proof cover, keeping the earth foundation drier and consequently giving it better bearing capacity.

Since these pavements were made of relatively soft brick varying somewhat in hardness and toughness, they soon wore to an uneven and bumpy surface. This wear could not be determined beforehand, for the Standard Rattler Test had not yet been developed. Furthermore, on account of the installation or extension of water, gas, or electric conduits, trenches were excavated in the streets which by being poorly backfilled, often left bumps or depressions in the pavement. In spite of all these defects, many of these old pavements are still in existence as evidence of the long life of this type of pavement. Several streets of this type now 30 years old are still giving good service with little or no maintenance and will probably continue to do so for years.

Introduction of Concrete Foundation

As the price of cement became lower, concrete was gradually introduced as a pavement foundation. At first the concrete was of a poor quality, but it increased in strength and uniformity as its use became more common and equipment for mixing it was improved. The development of the concrete mixer progressed from the continuous mechanical mixer to the batch mixer which is standard now and which has proved the most efficient for the production of good concrete.

MONOLITHIC BRICK PAVEMENT 9 FT. WIDE, 5 IN. SLAB, STOCKLAND TWP., IROQUOIS COUNTY, ILL.

Origin of Sand Cushion

The first concrete foundations being rough and uneven, made it necessary to continue the use of a layer of sand to take up their inequalities and provide a smooth even surface upon which to lay the brick. This was the

reason for the use of the so-called sand cushion, and was the origin of our sand cushion pavements, which are still being used except when cement filler is used between the bricks. As Portland cement became cheap enough to be used in pavements, various methods of obtaining a more smooth and even surface were developed until now the better class of work produces foundation surfaces varying little more than ¼ in. from a straight line. Thus we see the need of a thick sand cushion decreasing to the vanishing point.

Sand Cushions Work Up in Joints

After the brick were laid by hand in regular courses and rolled to a smooth even surface with a heavy roller, variations in the character of the sand cushion became evident. Some sands, if not previously compacted, worked up between the bricks, filling the joints from one-half to three-fourths full. This made little difference if the joints were to be finally filled with sand, but if a higher class or more expensive form of filler were to be used, it

DOES TESTING PAY? 12.2%, 35%, 43%, 11%.

often necessitated the taking up and relaying of the sections so affected. The importance of this became more pronounced as the filler became more rigid.

Kinds of Fillers

The three forms of fillers used are the sand or granular, the bituminous or plastic, and the cement or rigid, types. Of these, the first is the most simple and least expensive. It, however, affords no protection for the edges and corners of the brick but allows them to become rounded; making the surface of the pavement rough. With the abandoning of the lug brick except for rigid fillers, and the adoption of the straight wire-cut brick with its narrow joints, this objection has been almost eliminated. When the bituminous filler is used, applied in a hot and quite liquid state, little difference is made whether or not the joints are free from sand. The rigid filler, however, necessitates clean joints the entire depth of the brick, for otherwise serious trouble will be caused later on. As this is the cause of the greater number of brick pavement failures, it might be well to consider it more in detail.

Grout Filler

In the cement or "grout" filled pavement, it is essential that the joints be free from sand or other foreign material, and be filled the entire depth of the brick, thus cementing the separate brick into a solid slab. As the temperature rises and falls, the slab must expand and contract. Since the brick are in a solid slab having no allowance made for expansion, this expansion can take place only to a very slight degree, and instead great internal compressive stresses are set up. If the joints are filled solidly, the center of compression will be through the center of the slab, distributing the stress equally over the entire depth of brick. If, however, the joints are filled but one inch or less at the top, the stress comes entirely on this small section, and is often enough to shatter the brick or crush the cement filler, destroying the bond, and ultimately subjecting the entire pavement to wear the same as a sand-filled pavement. This failure by crushing, however, seldom comes in the entire pavement, but rather comes in spots where the grout had been carelessly applied, or of such thick consistency that it failed to penetrate the full depth. More wear is caused at these spots from the hammer-like impact of heavy wheels over the uneven surface, ultimately resulting in ruts or depressions.

Again, water penetrates these opened joints and its lubricating qualities combined with the vibration from traffic causes the sand to shift and compact, leaving a hollow space under this part of the slab. As traffic moves over this and adjoining sections, great shearing and tensile stresses are put on the grouted joints, ultimately causing their failure and consequently increasing the area of failure. Wherever expansion joints have been placed, this same action of water seeping in at the joint has caused the failure of the adjacent grouted joints, resulting in bumps, ruts, and crushed brick at each place. This destructive action is often hastened by the freezing and consequent expansion of water in the sand cushion.

Still another and often more dangerous occurrence, due to faultily filled joints, is the "blow-up." As the internal stress or pressure due to expansion increases, the resultant pressure, applied through the upper part of the brick slab maintains a great tendency toward upheaval, held down only by the weight of the pavement, since there is nothing in the lower part of the joints to resist. On hot days, this pressure sometimes becomes too great, and the whole pavement at the weak section is thrown up with great force, not unlike an explosion, throwing brick many feet in the air and endangering everything in the vicinity. It is with the elimination of these defects, then, that the engineers and contractors are mostly concerned.

Destruction Caused by Poor Filler

More miles of good brick pavement are destroyed annually by this careless, imperfect application of the cement filler than from all other causes put together. As before stated, when the sand cushion was used "inspectors" (many times political henchmen hard up for a job) often permitted repeated rolling of the brick, thus working the sand up very near the top of the joints. The result speaks for itself. West Irving Park Boulevard, Chicago, is a very good and recent example of this wanton destruction of good paving material by poor workmanship. Although it has been laid but 2 or 3 years, its surface, which should have lasted 30 or 40 years, in many places has been shattered or heaved by expansion stresses. Nearly every city has such examples, and Danville is no exception. We have a road running south from the city

toward Westville, which, although it has been built only about 10 years, has needed extensive repairs in certain sections only because of the destruction caused by the cement filler and by the use of expansion joints. The same is true of many of the streets in the city built in this manner. The inevitable result is that the modern vitrified paving brick, one of the best road surfacing materials made, has unwittingly been given an undeserved bad reputation, which will take years to retrieve.

It is on account of the seeming impossibility in many places of securing contractors who can lay a cement filled brick street properly, that the use of the cement filler has been virtually abandoned, and bituminous or sand filler adopted. These are practically fool-proof.

Cement-Sand Bed

To eliminate these undesirable features of the combination of the sand cushion with the cement grout filler and to retain the good features of the cement filler, a mixture of cement and sand for the cushion was substituted. Where the concrete foundation was finished to a smooth and even surface, the thickness of this cement-sand bed was reduced in many instances to as little as three-fourths of an inch. This pavement was a distinct type developed for city streets, and from the start was a great success. Its object was not only to afford a uniform bearing surface for the brick, but since the mixture of cement and sand was converted into a mortar by means of a thorough wetting after the brick were laid and rolled but not grouted, the setting up of this mortar finally formed a rigid bed and overcame many of the defects of the sand cushion. In addition, it effected to a limited extent a union between the brick surfacing and the concrete foundation, thus giving substantially a semi-monolithic beam. The success of this type of pavement on heavy traffic streets has earned for it a very enviable reputation.

Types of Monolithic Pavement

With the introduction of the monolithic pavement, there began a new era in brick pavement construction. Since the brick were laid immediately upon the fresh concrete base, the problem soon arose as to whether a sufficiently smooth surface could be obtained on the concrete to receive the brick. Two types of the monolithic brick pavement therefore came into use, differing in the method of smoothing the concrete surface. In one was used a thin layer of dry mix composed of cement and sand proportioned about 1:3, spread directly upon the concrete by means of a double template, and followed by the immediate laying and rolling of the brick; in the other this intermediate layer is omitted and the laying, rolling, and grouting of the brick takes place immediately upon the smooth surface of the concrete, obtained by the judicious use of sliding and tamping templates.

Monolithic Pavement Requires Experienced Contractors

Although, theoretically, this type of pavement was almost ideal, practically it proved very troublesome. From the start, uniformity of consistency of concrete became the bugbear of every road contractor on this work. Wet gravel, dry gravel, large, small, coarse and fine materials each acted differently, all operating to produce a wavy surface in spite of all efforts to the contrary. A stiff, dry consistency was finally adopted, with great success. It finally became apparent, however, that smoothness could only be obtained by careful, painstaking efforts, and had only been obtained by the most experienced and particular road builders. Although it was adopted by many states as the only permissable type of brick road, the concrete base was made so thick and the mixture so rich that on a price basis, competition with the usual one-course concrete pavements was out of the question, so the brick road lost out. Engineers finally saw their mistake and in some places reduced the total required thickness of slab to a rational figure. The monolithic type of pavement, however, is walking the plank in the wake of the sand cushion, cement filled pavement, and seems to be in the discard except in localities where careful and experienced contractors are available.

Five-inch Monolithic Slab a Success

One section of road noted for its radical design might be mentioned, however. In Stockland Township, Iroquois County, Illinois, a monolithic brick 9 ft. wide and 6 miles in length was built in 1916, using a 4-in. brick laid on a 1-in. bed of fine gravel concrete, making a 5-in. slab. Although this slab was laid on soil varying from brown silt loam to clay, sand, gravel, timber soil and gumbo, it was practically all underlain by gravel, providing good sub-drainage at all times. In this work a very smooth

A GOOD GROUTED BRICK PAVEMENT, LAKE SHORE BOULEVARD, CLEVELAND, OHIO.

surface was obtained. Although to date this road has gone through three winters, it is in perfect condition and stands as an example of the saving that can be made if we are only willing to take into account the natural drainage conditions that exist in the various sections of the country. In 1916, this work cost $8,500 per mile and provided a good profit for the contractors.

Resurfacing Easily Done Monolithically

Many of our old brick streets and country roads were built of soft brick that have worn rough under heavy traffic, making resurfacing imperative. This has been accomplished on the Danville-Batestown Road by brushing the dirt off the old brick surface and spreading a thin, smoothing layer of fine gravel concrete over it, upon

which the new brick surface was laid and grouted immediately. The old road, pounded down by years of heavy traffic, made an ideal foundation for the new brick wearing surface. Thus we obtained a new smooth wearing surface and a stronger road at half the cost of a new pavement.

Resurfacing City Streets Saves Money

To do this on city streets, however, involved additional difficulties in handling the surface drainage of intersecting streets. This was accomplished on Washington Avenue, Danville, which was a two-course brick pavement, by removing the upper course of brick and the sand cushion, spreading over the lower course of brick a smoothing layer of concrete not less than 3 ins. thick, placing a ¾-in. sand cushion on this and laying a 4-in. asphalt filled brick pavement on top. This was accomplished at a saving of about 25 per cent. to the property owners, and with the raising of the street level about 3 ins. This made necessary the installation of two additional storm sewer inlets to care for the drainage from an intersecting street, but did not impair the usefulness of the street in the least. Instead, it gave the city a heavy traffic pavement unequalled in carrying capacity and wear resistance.

POORLY FILLED JOINTS LEAD TO SHATTERED BRICK AND CAUSE TROUBLE.

Untested Materials Waste Much Money

Money has often been lost or wasted by the use of untested materials. Money spent in testing materials is money well invested, for it is an insurance against imposition and fraud. About five years ago, East University Avenue, Champaign, Illinois, was paved from the Illinois Central R. R. to Wright Street with an asphalt filled brick pavement, costing $50,000. Danville brick were to be used on the work, but for some reason only half the amount needed could be supplied at once so the remainder was obtained from a plant that has since then discontinued the making of paving brick. Danville brick were used from Wright Street to Fourth Street and the remaining distance to the railroad was paved with the other brick. No tests were made on this material, but within a year after laying, the section from the railroad to Fourth Street began to show signs of wear, and before five years were up, it was very rough. Samples of unworn brick were then taken out of the side of the street and tested. The results are shown in the accompanying photograph. The section built with Danville brick showed no wear, and maintained a smooth surface. They showed a loss of 11 and 12.2 per cent. in the Standard Rattler Test. The two samples in the center of the picture were of the second brick, which showed losses of 35 and 43 per cent. in weight. From the result of these tests it was decided to replace the greater part of these brick in the street with new material. More brick of the same make were obtained, tested, and rejected as unsuitable. Another lot was sent, but these, too, could not pass the test. Finally Danville brick were obtained and no further trouble was experienced. The lesson learned from this incident is expressed by the old saying: "'Tis better to pay grocery bills than doctor bills." It would have been much better to have paid for testing before the original pavement was laid than wait and have a $50,000 job go bad.

Rise in Prices Require Practice of Economy

The rising cost of labor, materials, and freight is leading to the practice of greater economy in street paving work for the coming year. With prices up 25 and 40 per cent. higher than those prevailing last year, tax payers are beginning to feel the cost of local improvements more than ever; and it is, therefore, necessary that every care be given to the design and construction of the street to reduce the cost to the lowest possible figures, consistent with safety. Wherever possible, old foundations of pavements are to be used, laying a new surface by methods similar to those used in the paving of Washington Avenue or the Danville-Batestown Road previously mentioned. In many places streets are repaved where the old paving brick are taken up and carted to the dump. Wherever possible and practicable, it is intended

to use these old brick by crushing, screening, and making into coarse aggregate for the new concrete base. The matter of crushing paving brick to be used in concrete for pavement bases is not, however, entirely a new idea. Detroit, Michigan, has used this in several instances and has obtained coarse aggregate from the paving brick at a cost of about 90 cts. per cubic yard. In Kansas City, Missouri, all old brick not suitable for use as a backing for building walls, were crushed along with all concrete from the old pavement base, screened, and used in a mixture of 1:3:6 concrete for a new foundation. This saved hauling the old material a considerable distance to a dump and saved the purchasing of new broken stone and it was estimated that the cost of the new concrete base was at least 25 per cent. less than it would have been if new material had been used. It was expected to find that this produced a weaker concrete than where new material was used, but a long series of tests of 8 x 15-in. concrete cylinders made from concrete going into the work showed that the crushing strength of the concrete, using old material free from fine particles, was practically equal to that of concrete of the same mixture using freshly broken stone. In Omaha, Nebraska, where some similar work was done, the brick were crushed at a cost of 65c per ton, including all overhead and depreciation charges. In all of these cases where such work was done, it was the general opinion that very durable concrete was obtained by such methods and that the use of the old brick in the new pavement base was not only practicable, but very desirable where prices of new material were high.

Protect Pavements from Damage by Car Tracks

We should not only practice greatest economy consistent with safety on the design and construction of our new pavements, but also with a view of protecting them from damage by poorly laid street car tracks. Nearly every city has more than one good example of the destruction of the pavement in and along car tracks by the improper ballasting of the tracks or by the use of faulty methods of construction in laying them. While it may not be more than just in many instances to allow the tracks to go to the bad, it is not fair to allow such tracks to ruin the paving of the streets on each side of them. We have, therefore, adopted in Danville, the use of concrete sub-curb built integral with the concrete base of the pavement on each side of the car tracks and extending downwards a depth of 9 ins.—sufficient to get below the ordinary gravel or stone ballast used and thus protect the pavement at the side from damage. The concrete base of the pavement between the car tracks and along each side of tracks is separated from the base of the street proper by a thin separation joint, while the space between the brick surface and the concrete base in and to the side of the tracks is filled with a cement sand cushion proportioned about 1 to 7. This serves to prevent this cushion from shifting after the pavement has been constructed, and also its use for a distance each side of the rail pre-

CONSTRUCTING NEW BRICK SURFACE ON OLD BRICK PAVEMENT ON WASHINGTON AVE., DANVILLE, ILL.
Top Row—Left: Old Lower Course Brick Ready for Concrete. Right: Spreading a Smoothing Layer of Concrete Over Old Base.
Lower Row: Spreading Sand Cushion—The New Surface Before Filling.

REMOVING TOP COURSE OF BRICK ON WASHINGTON AVE., DANVILLE, ILL.—BASE READY FOR CONCRETE ON SAME JOB.

vents the possible shifting and loss of the sand cushion under the street pavement. The cost of this method of construction is very little compared to the advantages gained by having this in use. If the car track does cause destruction, it will only destroy the pavement in and along the car track and will not affect the portion paid for by the taxpayers, thus fixing the blame for and confining the damage where it belongs.

Conclusion

Pavement construction has passed through one experiment after another since the introduction of the old flexible base brick pavement years ago. With the increased use of cement, concrete foundations and cement fillers became popular. Now considering the high price of cement and other roadbuilding material and benefitting by the years of experience with these various types of pavements, we are coming back to the old practice—flexibility rather than rigidity in pavements. We must not act thoughtlessly, however, in the designing of our new streets. There are many questions to be settled before we approve such a pavement. True it is that many of our old streets have lasted longer and have given better service than some of the new but *would they* if they were subjected to our present day heavy traffic? Are we saving enough by their use to warrant it? Can we not put more money in sub-drainage and cut down our paving cost to a greater degree thereby? Are not rigid pavements best for heavy traffic? All of these are vital questions and must be satisfactorily answered before we adopt flexibility as our motto. We have made radical changes before—hence such are not impossible again. "Look before you leap" has been an oft' repeated motto that is peculiarly applicable here.

SOME ECONOMIC QUESTIONS AFFECTING HIGHWAYS

By J. E. Pennybacker, Secretary of the Asphalt Association, 15 Maiden Lane, New York, N. Y.

With 1920 forecasted as the greatest road-building year in American history and with the estimate of road revenues running to three-quarters of a billion dollars not including funds of cities and villages, economic problems assume greater importance than ever before. There must be no reaction through an orgy of spending simply because the money is in hand. Now, if ever, is the time for weighing carefully the economic justification of each highway project to ascertain whether it is worth the money and whether the design is appropriate. Some of our highways must cost forty and fifty thousand dollars a mile but they should "show cause" unmistakably.

Economic Highway Surveys

Time was when every dollar had to go to the primary purposes of giving us merely a place upon which man and beast and vehicle could find space to progress. In those days systematic study of the service possibilities of each highway and the establishment of a schedule and budget bulked too large as to initial cost. Today I believe each state could feature economic highway surveys as a preliminary to any considerable expenditure on highways, such survey to present comparative data on traffic, actual and potential; the service value of the highway to the communities for protection, educational progress, and pleasure travel; the salvage value of improvements already made; the possibilities of keeping money circulating locally by utilizing local materials and local industry; the comparison of the tax burden for interest, retirement, maintenance and renewal with the use to be made of the highway. In short, we are now spending enough to justify preliminary tests which formerly would have seemed costly and elaborate.

Highway Design

Highway design now is of most far-reaching concern, not only as it affects cost of construction, but also in its relation to the motor vehicle. Government tests have been referred to as showing the tremendously destructive possibilities of impact of heavy trucks. Thus it has been stated that a weight of 7,750 lbs. on a truck wheel with a speed of 15 miles may be equivalent to a static load of 43,000 lbs. if the wheel has a drop of 1 ins. Are we to design slab types of pavement to hold up a 43,000-lb. load? If so, even America's purse will not foot the bill.

Resilient Foundations

Just now stress is laid upon the possible "cushioning" effect of asphaltic surfaces with a view to "absorbing" the shock rather than transmitting it to the base. Other eminent authorities while not supporting the "cushion" theory say there is much to the claim that bituminous mixtures may have very great beam strength under suddenly applied loads—that is to say the impact. There are those who point to bituminous and water-bound macadam foun-

dations as distinctly superior to cement-concrete foundations and so general is this disposition to regard the foundation question as still a wide open one that the American Road Builders' Association recently voted unanimously against reporting in favor of recommending one type of foundation for trunk roads. When it is considered how stupendous a sum is involved in this question of highway design does it not seem urgent to make available at once as many hundred thousand dollars as are necessary to reach sound conclusions quickly, instead of following abstract formulas based upon beam strength assumptions? The Federal Bureau of Public Roads should have many times its present facilities and funds to work out this problem of highway design.

Vehicle and Gasoline Conservation

Now what also of the vehicle and its conservation? Highway surfaces must affect the wear of tires and the annual tire bill is estimated at upwards of a billion dollars. Ten per cent. reduction in tire wear would capitalize a billion dollar highway program and leave plenty of funds for maintenance.

And what of our gasoline consumption? Eight million cars will burn up gas at a more rapid rate if tractive resistance of the highway surface is high than if it is low. How much can we reduce the gas bill by designing suitable highway surfaces? Much, undoubtedly. Shouldn't the automobile industry be concerned in getting the public and the officials of the states and national governments to co-operate in such a study?

Co-ordination

The economic necessity for co-ordinating state systems of highways by a more effective national policy will bulk larger in 1920 because the need will grow more pronounced.

Fitting the parts of the road-building machine—the car supply; the manufactured product supply; the contractor and labor supply; the engineering supply; will put many a strain and jar upon the whole fabric, for never was it called upon for an effort comparable to that of this year. Why not a clearance committee of state officials to help this co-ordination instead of each state battling each other state?

Treatment of roadsides and questions of right of way, as time goes on, increasingly affect the economic value of the public highway. Roadside treatment does not involve merely beautification by the planting of trees and shrubs, but the much larger questions of protecting the highway itself through the planting of slopes to prevent slipping, the planting of trees and shrubs to prevent erosion and the protection of the highways against adverse weather conditions, this requiring in some cases planting and in other places thinning. It involves, with the enormous increase of motor traffic, some very positive measures for the protection of life through giving clear vision at dangerous curves and crossings; the prevention of encroachment upon right of way by structure, vegetation or sign boards. With a little breathing spell from the tremendous drive for construction records much needed attention to the economics as well as the esthetics of roadside treatment will be given.

There is sounding a continuous call for wider highway surfaces to meet the dense and fast-moving traffic. Wider surfaces cannot be had in most cases without wider rights of way. Property is increasing in value all the time and every year it costs more to secure additional rights of way. This question then assumes a very important economic status, for certainly if more space must be had the sooner we obtain it and the lower we can keep the initial cost, the better business it is, and if we can protect traffic by giving it more room in which to operate we are rendering a service which cannot be over-estimated.

Signposting Highways

Now that highway traffic is crossing and recrossing state lines to such an extent as to make the interstate traffic as great in many cases as the intra-state traffic, common sense dictates the necessity for an interstate agreement among our highway managers to so sign-post and mark the highways as to have the same symbols, the same colors and the same general design apply with equal force in all states. It is an unnecessary bit of confusion for the traveler to find that a series of red, white and blue bands on telegraph poles means in one state a particular memorial highway and in another state may simply mean direction. It is confusing and even dangerous for him to encounter advertising signs so designed as to simulate danger signs when the purpose is primarily advertising and the danger is remote. Many states have made great progress in sign-posting and marking their highways, while organizations have done much along national lines, but there remains the necessity for the official adoption of a national or interstate system, by concurrence of the appropriate state representatives. Nineteen-Twenty would be a suitable year to bring this about.

Federal Aid Policy

Congressional appropriations for Federal Aid have been made to cover the period up to and including the fiscal year beginning July 1, 1920. Either Federal Aid on its present basis is sound, or it is not. One thing is established and that is the conviction in the minds of the American people that the Federal Government should continue to be an active participant in highway work. The year 1920 should thresh out pretty thoroughly the economic merits and demerits of the present Federal policy and Congress should reach the point of at least initiating a broad policy in 1920 to become effective in 1921 as a successor to the Federal Aid Road Act. The question of a national highway system versus the Federal Aid plan is too important to be left to snap judgment and there is time if action is taken now for Congress to have before it next winter an exhaustive and comprehensive report by a competent board of engineers and economists as to what should be the appropriate Federal policy for 1921. Should not the creation of such an investigating board be one of the economic provisions of 1920?

All of these problems will be solved in due time, but let us consider them as today's problems and not wait until we "have time."

PROPOSED SCHEDULE OF SALARIES FOR ENGINEERS IN STATE HIGHWAY SERVICE

By A. N. Johnson, Chairman of Committee of American Association of Engineers on Salaries of Engineers in Public Service.

(Editor's Note:—The proposed schedule of salaries for engineers in state highway service was published in

full in the November issue of Municipal and County Engineering and attracted much favorable attention. The present paper by Mr. Johnson was presented at the recent annual convention of the American Association of State Highway Officials. The Association just named passed a resolution approving the proposed schedule. The other members of the Committee of the American Association of Engineers on the Salaries of Engineers in Public Service are: S. C. Hadden, Editor of Municipal and County Engineering; H. G. Shirley, Secretary Highway Industries Association, Washington, D. C.; J. H. Prior, Consulting Engineer on Public Utilities, Chicago; A. R. Hirst, State Highway Engineer of Wisconsin, and F. H. Newell, President of the Association).

The salaries of engineers in state highway service as proposed by the Committee of the American Association of Engineers on Salaries of Engineers in Public Service have been sensed as the result of observation and judgment rather than the result of any precise mathematical investigation.

Basis of Salaries Recommended

The basis upon which the list was built is, briefly, as follows: First, there were established salaries for three places in the schedule, the highest, a middle position and the lowest.

The highest position, that of chief engineer of a state highway department, it was felt should command in many cases fully as much as paid to chief engineers of railroads, and in fact should command more than chief engineers of other than some of the largest railroad systems.

The middle position was considered to be one requiring an engineer having at least four or five years' experience since graduation from college; a man who it may be expected will be married. Such a position should, therefore, carry with it such a salary as to enable a young engineer with a small family to live in comfortable and appropriate surroundings.

This point in the scale is perhaps more difficult to arrive at than either the highest or the lowest position, but in general it is the sense of the committee that such a position should receive not less than $3,600.

The lowest position was taken as one to be filled by a young man just out of college with the reasonable expectation of a raise in his salary at the end of six months. Such a position it was thought should command a salary not less than $1,200 to $1,500 per year.

The three points thus established are: highest, $8,000 to $15,000, the middle, $3,600 to $5,000. and the lowest, $1,200 to $1,500. With these established the other positions readily fall into line.

An examination of the salaries will show that it is expected that engineers will be gradually increased. Among assistant engineers it is expected there will be employed engineers having from 3 to 5 or 6 years' experience, thus the range of salaries in such positions is made from $2,400 to $4,000. All first assistant engineers, it is assumed, would be men of sufficient experience as to require the minimum for the middle position, that is, $3,600, with the range of $3,600 to $5,000.

The inspection service has been made a group by itself. This was done purposely by the committee to give emphasis to the importance of this service and to call special attention that such positions should not be filled by inexperienced men. The young man just out of college is not competent to serve as an inspector. It is assumed and it will be noted from the salary schedule where the inspectors of construction are rated $2,400 to $3,600, that these positions should command college men with not less than two or three years' experience or men of practical experience competent to be foremen.

In all positions commanding over $3,600 a year, the test as to what additional salary is to be paid is based upon the relative degree of administrative and executive responsibility the different positions involve. The general division of the positions indicates this basic classification. Thus, there is first shown what are considered as peculiarly administrative and executive positions calling for men possessed not only of technical skill but of practical experience, combined with administrative and executive ability. The individual engineer not possessing such attainments cannot expect to command the salaries attached to positions requiring such ability.

Application of the Schedule

This list of recommendations in regard to salaries of engineers in state highway service should be examined, not as an outline for an organization that is required or necessary in each state, but rather as a list of positions with corresponding salaries, from which may be selected a sufficient number of units to make as complete an organization as will be required by any state highway department. In order to do this, it was necessary, or seemed advisable, to enumerate a number of positions which would appear to be identical, so that it would be the easier for any department to fix readily the salary of any position in the department in accordance with the recommendations made by the schedule.

Thus the department which has a comparatively small amount of work and requires therefore a relatively smaller organization will find many positions listed, particularly among the administrative positions, that will not be required; and in such instances probably would pass immediately from the position of state engineer to those listed as first assistant engineers.

Universal Features of Schedule

There is no state having a state highway department where the state highway engineer cannot render a service to the people of that state worth at least $8,000 a year. It is also true that a rodman, whether working with the smallest or the largest organization, is individually worth as much in the one class as the other. The difference lies merely in the fact that there are more rodmen connected with the larger organizations than with the smaller. Similarly, the individual inspector, whether connected with the small or large organization, can inspect properly only so much work and is worth as much in the one case as the other; again the difference being merely in the number of inspectors to be employed. The number of inspectors and the number of rodmen will in turn determine the number of men required for the higher positions. Thus, when examined in this light, the salaries as here proposed apply with equal force to the largest as well as the smallest state highway organization.

The only difference would perhaps lie in the application to be made of the range of salaries in the lower positions and in the higher positions. In the lower positions the range shown in the salaries is to be interpreted to indicate the opportunity for promotion in the positions named, whereas in the administrative positions the range in salary is to be interpreted more to differentiate between larger and smaller organizations for which the positions are considered. That is, it is assumed the larger organizations impose a greater responsibility and therefore the chief engineer should command a higher salary than in the instance of a smaller department.

Schedule Given Publicity

In order that the committee might have the fullest information from which to prepare its report, the list of salaries for engineers in the state highway service has been circulated widely, particularly among all the state highway departments, has been published in a number of technical and trade papers and criticisms invited from every source. In general, the criticisms made have been favorable and the schedule approved.

In a few instances critics have suggested changes. In particular the salary attached to engineer of bridges, recommended to be from $5,000 to $8,000, has been criticised by a number of bridge engineers as discriminating against this position, which it is contended should carry a salary that would indicate the position to be of equal importance with that of the engineer of construction or engineer of maintenance. The committee gave this criticism careful study and, after consulting with a number of chief engineers of different state highway departments, was of the opinion it would not be warranted in making the change suggested.

Short Sighted Criticism

If practical results are to follow suggestions of the American Association of Engineers regarding salaries of engineers in public service or in any other service, the first essential is unity of opinion and purpose amongst engineers themselves. One of the chief drawbacks to higher salaries for engineers in public service has been in the past the opposition of these very engineers themselves. This may seem at first paradoxical but here is an instance: A legislative committee gives a hearing on the subject of salary increases for a certain position and behold there appears before the committee a number of engineers who state that even lower salaries than those paid at present are paid to many engineers and that engineers may be easily secured for the present salaries. What is a legislative committee to think? The engineers who make such statements do so usually from jealousy. It is frequently some engineer who has been disappointed in securing an appointment and cannot see that what is for his brother's welfare will be the most powerful argument and means to increase his own income.

That engineers may be united and present no conflicting testimony and make no contradictory claims is one of the purposes of the American Association of Engineers. I hope you will urge your associates to join the Association and become a real factor not alone to help yourselves but to do so by helping others.

The basic idea and purpose of the schedule is to secure a salary for the man who selects a career in highway engineering that will reasonably assure him, under present conditions, an opportunity to support and educate his family in a modest way. As we reach those positions that demand a wide experience and special accomplishments which make the engineer of judgment and administrative ability, the salary to be paid should represent the value of the service rendered to the public and be commensurate with the responsibilities imposed.

THE CONSTRUCTION OF ASPHALTIC ROADS IN THE PANAMA CANAL ZONE

With that foresight and broad comprehension which characterizes the success of all development, the United States Government is enhancing the commercial value and prestige of the Panama Canal Zone in a thorough, methodical manner. Beautification of the various communities, the erection of comfortable and attractive dwellings, and the construction of modern, durable highways forms part of the program which is intended to put the Canal Zone in a position of commercial and industrial prominence, to make it a veritable hive of pulsating activity, and to offer it as a place where ambitious men can achieve success and prosperity.

The importance of the Panama Canal has been recounted extensively, and all persons are cognizant of its inestimable value to the United States. As the gateway

FIG. 1. SHEET ASPHALT WEARING SURFACE LAID ON A CONCRETE BASE ON THE HIGHWAY THROUGH PEDRO MIGUEL, PANAMA CANAL ZONE.

between the Atlantic and the Pacific, it is one of the bulwarks of American maritime commerce; it has given stimulus to this country's trade and prosperity, and it stands as a monument to the Government's ability for achievement. In close association with the Canal itself is the development of the Zone which is under the government of this country, and the plans for this development have been worked out with the same wise, careful foresight that led to the accomplishment of the waterway itself.

Perhaps no phase of the development of the Canal Zone has been given more attention than the all-important matter of highways. Realizing the close inter-relation of good roads and prosperous advancement, the Department of Operation and Maintenance has laid out a broad, comprehensive system of highways, which not only provides excellent streets of durable type in the cities and

towns, but also provides lasting roads between one community and another. The military posts and quartermaster stations, too, are surrounded by roads which will stand up under the terrific wear and tear of the numerous automobile trucks which furnish one of the most used means of transportation in the Canal Zone. It has been considered all-important, furthermore, to provide connecting links between the various communities so that automotive traffic will not only be encouraged, but so that the inhabitants will get the domestic advantages and comforts of rapid delivery of foodstuffs and other commodities.

Sheet asphalt and asphaltic concrete streets and highways have been built in the towns and on the main links between communities. The construction of these arteries

FIG. 2. A SECTION OF THE ANCON-PEDRO MIGUEL HIGHWAY; CONCRETE BASE, SHEET ASPHALT WEARING SURFACE.

of traffic was done not by private contractors, but by government forces under government direction. The thickness of the asphalt wearing surface was 2 ins., laid on concrete foundation of 6 ins. thickness, with one quarter of an inch to the foot as a crown. The concrete curb and gutters were poured as part of the slab.

One of the economic features of this highway construction is the fact that native sand is available to be mixed with the asphalt. This obviates the necessity of paying freight rates and haulage charges, and results in economical construction. During last season large yardages of Texaco asphalt were laid at Pedro Miguel and on the Ancon-Pedro-Miguel-Miraflores Road.

THE DESIGN OF MODERN ROAD SURFACES, WITH ESPECIAL REFERENCE TO ALIGNMENT, GRADE, WIDTH AND THICKNESS

By Charles M. Upham, Chief Engineer, State Highway Department, Dover, Delaware.

In the consideration of practices influencing the design of modern road surfaces, with especial reference to alignment, grade, width and thickness, this article will deal with generalities, and will not consider specific cases, for it is evident that it would be impossible to recommend any definite method or practice, within narrow limitations, at least, that would satisfy all conditions, as they vary throughout the entire country.

Rules to Follow

When the problem of the design of highways is taken into consideration, there are several rules that can be followed and accepted as the best practice; these rules are the result of years of experiment and trial; and if followed will assure ideal results and conditions; but in every locality, there will be varying conditions and local influences, which will make it impossible to follow consistently these fundamental rules of road design.

General Considerations

Almost the first step in the design of a highway, is the study of its location; keeping in mind the purpose

FIG. 3 MAIN STREET, PEDRO MIGUEL, PANAMA CANAL ZONE, ASPHALTIC CONCRETE PAVEMENT.

which the particular highway is to serve. If the highway is constructed as a scenic road, then the problem is well defined, but if the highway is to serve as a lane for commercial and industrial traffic, then the problem becomes more complicated and careful study is necessary in considering the question of how local traffic can best be served without lengthening thedistance, and introducing curvature. At the same time, the question of grade must be considered in connection with the alignment. The ruling and intermediate grades kept within an economic per cent.; the total cost of grading should also be considered. The location of road revolves itself into the problem of economic compromise, depending on the solution of these factors.

There are a few localities where ideal alignment and grades can be secured, but in most places local conditions and limited topography make it impossible to attempt this ideal alignment, but still the inclination to lean towards the ideal alignment should always exist, though it be impossible to attain it completely.

There are more variables affecting the problem of width of roadway than in the choice of alignment and grade. The width of highways should be dependent upon the alignment and grade, as well as upon the amount and character of traffic, and the character of the roadside.

Economic Thickness

In considering the thickness of the pavement, there are several features that must be taken into consideration before a final decision can be made. With unlimited funds, it would be a simple problem to select a thickness of pavement that would carry all traffic, but the problem is to design the economic thickness, a pavement that will carry the load without any surplus thickness beyond a reasonable factor of safety. Of course the thickness of a given type of pavement is dependent upon the character, number, and weight of the vehicles that it must carry, as well as the character of the soil in the subgrade, and the possibility of keeping it completely and quickly drained.

Prevailing Practice

In order to keep the consideration of the above subject general, and in order to form a nucleus about which recommendations and practice could be discussed, I took the liberty of writing to several state highway departments, located in different sections of the country, and asked their practice in the design of roads with reference to line, grade and thickness. The replies show that on alignment and grade, most of the states were traveling along the same general direction; some approaching nearer than others to the ideal condition. When the question of widths was taken into consideration, it was noticed that in those states, in which were located the largest number of cities, and where traffic had become excessive, and the demands for more room had been felt, wide pavements were being constructed.

A uniform thickness of pavements seems to have been followed by all the states, with the exception of those in which were located cantonments. In these particular cases, a greater thickness of pavement has been adopted.

Alignment

In giving consideration to alignment, roads may be divided into two classes; the one, being roads located within parks, and intended as scenic roads and used mainly by sight-seers and tourists; the other being roads that can be considered as commercial or industrial roads, which would be located within and between business centers, towns, cities, etc.

In the alignment of the park or scenic roads, it is not essential to have long tangents nor direct routes; the only essential requirements of these roads, are that they shall furnish lanes of travel for pleasure riders, and shall be properly designed and constructed from the standpoint of safety and beauty. These roads need not be laid off in direct routes, because speed or time is not generally an element to the users of these highways.

The controlling points of the scenic road are entirely different from the industrial road, and consideration should be given beautiful views; preserving of trees; the regard to costly residences, and in fact, any detail that may serve the purpose of making the road more beautiful. With the controlling points fixed, the only other consideration is that of safety and the expense of construction.

There seems to be a practice among practically all the states, that from the standpoint of safety, the alignment of the scenic roads should be such, that the radius of all curves should not be less than 300 ft.; though in many instances it is common practice to use radii of 200 ft. or less.

The commercial road may be described as that road that will most economically serve the commercial or industrial requirements, or defined in another way, may be called the direct route.

In considering the alignment of commercial roads, or direct routes, it must always be remembered that a straight line is the shortest distance between two points, and from a commercial standpoint, the shortest way is not only the most direct, but with other things equal, is the most economical; therefore, it seems to be practically conceded that ideally aligned commercial roads are those that are laid in absolutely straight lines.

Where there are costly influences entering the problem that make it impossible or impracticable to follow the straight line, then the alignment should approach the straight line, and become a compromise of line, grade, and cost of construction.

By the straight line method it does not mean, that two distinct points should be given ultimate consideration, but each and every community and business district lying between these points should be given due regard, and the line should run in the most direct line possible connecting up these intermediate controlling points, provided the line will form a direct route.

More stress has been laid upon the alignment of roads during the past two or three years than ever before. It simply shows that highways are passing through the same stage that the railroads passed through when after exhaustive studies from an economic standpoint, they spent considerable money for the straightening of their lines. The problem of the highway is practically identical with that of the railroad. Much study should be given to final location, for after all, the location of a road is the only permanent detail; therefore, this should approach the ideal as closely as possible.

In the construction of hard surfaced roads, the alignment is well defined, and very little change or slight angle can be plainly seen. If breaks in the line are necessary they should be located on the tops of hills or summits in the grade.

If necessary to use a curve, then the flatter the curve, the safer the road, and this would not jeopardize the beauty or purpose of the road in any way.

When a curve sharper than 4 degrees, or of 1433 ft. radius, is used, the roadway should be elevated on the outer side, and widened on the inner side. This will overcome the tendency of the traffic to skid and make driving both safer and more pleasant.

A very important feature in deciding the alignment of roads, is the consideration to the through traffic. The ideal road is one that will serve through traffic by direct routes and also make it possible that this traffic need not be delayed on account of congested districts. In other words, the best alignment for a through traffic road, is a straight line so located as to pass near, but not pass directly through these congested districts. With such a location, the through traffic is not subjected to interference or delay which is always present in the main thoroughfares of towns and villages, nor on the other hand is the town or congested district subjected to the hazard of the through traffic. By such a location the congested districts have all the benefits of a modern highway, but are not subjected to its disadavantages. Therefore, when considering alignment, this is a very important detail to keep in mind.

Under alignment, there may also be mentioned the subject of the width of right of way. This we find in nearly every state has been neglected or it has given considerable trouble, when road developments have been carried on in a modern way. Until recently only in a few states were right of ways obtained wider than 40 ft., or was there any amount of effort made for direct routes or straight lines.

With roadway sufficiently wide to take the amount of traffic and to add to this such space as is generally necessary for shoulders and drainage, a minimum right of way of 60 ft. should be obtained in districts outside of cities and towns, especially if the country is at all rolling.

When the smaller towns are approached or entered, the right of way of sufficient width to allow for the widening of the roadway to take the additional traffic, should be obtained, as well as sufficient width for the carrying into effect of any beautification scheme, such as grass plots, flower gardens, tree planting, etc., that might be developed at any time in the future.

In the case of cities, it is quite advisable in the construction of any road to secure, as soon as possible, sufficient width of right of way to provide for future development, such as might include wide sidewalks, grass plots, areas for tree planting, besides sufficient roadway to take care of the ultimate traffic.

It may possibly be said that through many villages and small cities it would not be practical to secure such width of right of way as recommended, especially after developments in property have been made.

This might be true if it was necessary to bring around this condition immediately, but this could be provided for ultimately by establishing new building lines or property lines, making it compulsory that all future developments and re-building should be a certain distance from the road. In this way, a wider right of way would finally result, with the expense of an immediate change.

It may be said that a highway, as a factor in transportation, is no more economic or efficient than its ruling grade.

Grades

Grades and alignment seem to be so closely related, that many times one is dependent on the other, or one is bettered at the expense of the other. In any case, the ideal conditions should always be kept in mind, and a compromise wherein the maximum of an ideal condition should result.

The same general division can be made with regard to the choice of grade as to line, namely; scenic roads and commercial roads. On the scenic roads, safety and beauty seem to be the controlling factors, while on commercial roads, the problem is an economic one, and the requirement is that traffic should use the road at a least cost or effort.

In designing the grades for highways, there seems to be a general tendency for the states to make an effort to limit the maximum or ruling grade to 6 per cent., with the possible exception of short stretches, which seem to be allowed in most states. This 6 per cent. grade was established in the days of horse drawn vehicles, and while it has served in that purpose, it has not been definitely established at least that this is the most economic grade for motor vehicles. A maximum or ruling grade for motor vehicles is the steepest grade that can be negotiated with minimum of power. This problem is now being studied but it can only be determined after careful study and experiment and close co-operation with the motor industry.

In most states it is impracticable and almost impossible to hold to a grade as low as 6 per cent. and in these cases, if a grade considerably in excess of 6 per cent. seems necessary, a study of relocation should be thoroughly made with an end in view of reducing the grade. It is economic to increase the length of line if a reduction of grade will result.

At the beginning and end of all grades, vertical curves should be used in order that the grades shall preserve a continuity and can be approached gradually, as well as provide a long line of vision. There is one definite conclusion, however, that we can draw relative to grade; the power to negotiate the grade increases proportionately to the per cent. of grade. With this law established, we can see that the level grade would be the ideal grade from an economic standpoint. With this definite law, the problem of grade is somewhat simplified and can be determined. In many cases, more power is absorbed in overcoming the surface resistance than in overcoming the grade.

It was often thought, that before a grade or hill was improved it was the grade that was causing the resistance, when as a matter of fact the road surface probably caused many times more resistance than the grade. With an unimproved surface the grade resistance is a small percentage of the whole resistance; with an improved road, the grade resistance forms a much larger percentage

of the whole, showing the necessity and economy of reducing grades, if we wish to retain the advantage when hard surfaces are constructed.

After establishing the level grades, as the ideal economic grade, all efforts should be made to approach this grade in the design and any compromise with line or expense of construction should be made with the ideal grade in mind.

Widths

While the requirements of widths of pavement can be divided into demands for scenic widths and commercial road widths, the demands and requirements are so closely associated that only commercial roads need be considered.

While the width of pavement can be said almost wholly to depend upon the character and amount of traffic, the problem still remains far from being solved on account of its being affected by the variable known as the personal equation; something impossible to solve.

The worst condition that generally exists on a road is when wide trucks are placed side by side. The average width of the wide truck is 8 ft., so it can be seen that two trucks would theoretically just take up the entire space above a 16-ft. road. Practically, however, due to the overhang over the wheels, these trucks might be placed on the pavement so there would be a 2-ft. clearing between the bodies, provided each truck went to the extreme edge of the pavement in passing. This, however, is not often the case, due to the fear of getting too close to the edge of the roadway, and the condition of the shoulder being too uncertain. For this reason it can readily be seen why most states have already relegated to history, the 16-ft. roadway, and stepped forth to 18 or 20 ft. for a double track road.

For a two-track roadway, nearly all states are now advocating 18 ft. with a minimum shoulder on each side, 3 ft. in width. A few of the states still adhere to a roadway of 16 ft., but in this case, shoulders are always provided whereby the traffic may readily ride on the shoulders, provided it is necessary.

In a three-traffic road, many states adhere to the 24 ft. in width, but there seems to be a growing tendency that this should be increased to 26 or even 30 ft.

The reports of the American Road Builders' Association, covering this subject of widths, recommend that a double traffic trunk highway should be at least 20 ft. wide with a minimum shoulder of 5 ft. Wherever there is an additional line of traffic, 9 ft. should be added to the roadway. Wherever the right of way can be acquired, provision shall be made for shoulders of at least 9 ft. in every case. This is for the purpose of future widening of the roadway when necessary.

To widen a roadway to certain limits is a step in the ideal direction, but it cannot be said that a roadway should be widened without limit, for after a certain width is reached, and traffic becomes heavy, lanes for traffic should be established, and furthermore, separate lanes for the fast traffic, as well as the heavier or slower traffic should be set up.

The cost of road enters strongly into the determination of width, and when the compromise is made, the minimum should be sufficiently wide to take care of the lines of ordinary traffic, plus as much clearance width as the importance of the road and the intensity of the traffic justifies.

Regardless of width of roadway, the shoulders should be maintained in a serviceable condition for cases of emergency. If the roadway is not sufficiently wide to provide for traffic, the shoulder will receive considerable of this traffic, and cause excessive maintenance. Many times this excessive maintenance would pay the cost of construction of a wider roadway, which would result in a much lower shoulder maintenance and provide a more satisfactory pavement.

In level countries where alignment is straight and the curve flat, there seems to be no necessity for an increase in width from the general widths required for the various number of lines of traffic, but in countries where the alignment is not straight, it is quite essential that the width on all curves of 10 degrees and over should be materially increased.

The width of increase on pavement should take place on the inside of the curve and begin at a point outside of the point of curvature and extend beyond the point of tangency. The additional width varies according to the degree of curve and local conditions.

Many states have after deciding upon their unit of width made their width of road entirely dependent upon the amount of traffic. Where the traffic is up to 3,000 or 4,000 vehicles a day, the roadway is not less than 18 ft. in width; where the traffic averages about 5,000 vehicles and over during the day, the roadway is made at least 26 ft., and sometimes 28 or 30 ft. In this instance satisfactory shoulders should be provided for the chance or accident that the traffic is forced off the metal roadway on to the shoulders.

Some states have decided that if a hard surfaced pavement is to be used, the minimum roadway, in order to provide for a single line of traffic should be at least 9 ft. in width and preferably 10 ft. A pavement of this kind should not be attempted unless there are satisfactory shoulders of sufficient width and character whereby vehicles can pass without danger, or, that turnouts should be provided at intervals.

Thickness

To make any specific recommendation as to the necessary thickness of this pavement would be attempting to solve a problem wherein there are two or more variables, for the thickness of a pavement not only depends upon the demand of traffic that this pavement may be subjected to, but also depends upon the type of pavement and the conditions of the subgrade and drainage system, which influence not only the strength of the pavement, but its resistance to withstand the numerous and varying loads. With the old pavements that were designed to withstand merely the demands of the lighter vehicles, practically all failures were due to the wear of the surface. As the loads upon this pavement were increased, the pavement broke down from the very fact of being unloaded, and it was not a case of the pavement wearing out. This would seem to indicate that a pavement of a strong compressive strength that will withstand heavy loads as well as hold up when the pavement is acting as a beam, is demanded.

Pavements are called upon to withstand compressive stresses, to resist stress, set up, when the pavement is subjected to beam action, or to resist shear stresses. It seems that most of our pavements have been so designed as to withstand the compressive and shear action, but the greatest trouble has been found in attempting to design a pavement that will withstand stresses when the loads bring about beam conditions. Of course it will be a simple matter to design a pavement that will act as a beam and withstand any load, provided it is not necessary to keep in mind the necessity of keeping the cost within moderate limits. In order to determine the thickness of pavement, considerable effort has been attempted in the way of distributing the weights or force over a large area.

Other experiments have been made using a cushion in attempting to overcome impact and produce resiliency.

Almost the first step in designing a pavement must be to assume the nature and condition of the subgrade; the better the subgrade, the thinner it is possible to make the pavement.

As the conditions of the subgrade become worse, the thickness of the pavement must be increased, so that on account of the changing conditions of the subgrade, our first assumption is full of variables. Generally the design is not changed for each condition of subgrade, but the worst place is considered and the entire pavement designed from these conditions; this, of course, is uneconomical.

The ideal limit would be to have a perfect subgrade. Then only a thin surface of road would be required. As the subgrade became worse in character, the thickness of the road surface must be increased for the purpose of distributing the loads over a wider area. A popular method of load distribution has been the use of a rigid base such as concrete.

While in many designs it is assumed that the stresses travel from the load to the subgrade in lines of 45 degrees to the surface, actual experiments show that in a concrete surface, the lines of stress reach as far as 6 ft. from the load application; this means that the load is sometimes distributed over a 12 ft. area.

Now the problem is to design the road to take care of compression; punching shear, and beam action. Taking into account the distribution of forces produced from the load application, either a concrete, or a concrete base pavement, surfaced with bituminous material, will overcome the compressive requirements, and the minimum of designs, supported by a satisfactory subgrade, has always cared for the punching shear.

It would seem that an economic pavement could be one of a material such as concrete and capable of distributing loads, laid on a carefully prepared subgrade, designed as previously described, and if this pavement should be subjected to excessive impact, it could be covered with a bituminous surface. This would mean a bituminous mat that would absorb impact and transfer the loading to the concrete which in turn would distribute the load over the prepared subgrade. Where the subgrade was prepared as described there would be a slight chance of its shifting, which would mean that the span between supports would be small, which would further mean that a much thinner concrete distributing layer could be used.

Conclusions

In order to crystallize the points of this article on line, grade, width and thickness, the conclusions of this paper may be drawn:

Alignment.—On scenic roads the straight line is not absolutely necessary but all importance should be laid on safety. On commercial roads the straight line is ideal and all roads should approach this alignment.

Grades.—While the grades on scenic roads should be held low wherever possible, the ideal grade on a commercial road is the level grade. Whenever a road surface is changed from earth or macadam to hard surface, the grade should be materially reduced if it is desired to retain the advantage of a hard surface.

Width.—The minimum width of a two-way traffic road should be at least 18 ft. and an additional width of 9 ft. added for each line of traffic; suitable shoulders should be provided in all cases. After a four or five-way traffic is reached, the roadway should not be increased, but lanes for the separate lines of traffic should be constructed. All curves sharper than 10 degrees should be widened and banked.

Thickness.—While thickness is dependent on type of pavement and nature of traffic, it is also closely identified with condition of subgrade. To better the subgrade, means the possiblity of reducing thickness of pavement, which seems to indicate it might be more economical to spend money preparing subgrade, than to attempt to support the loads by blindly increasing thickness.

The foregoing paper by Mr. Upham was presented at the recent annual convention of the American Association of State Highway Officials.

THE SMALL ENGINEERING JOB—A NEW CONCRETE FLOOR IN AN OLD BUILDING

By E. McCulloh, of the Charles L. Pillsbury Co., Metropolitan Life Bldg., Minneapolis, Minn.

The Small Engineering Job

Comparatively early in his career, the writer learned that while, with the wealth of descriptive matter available, it would be easy for him to equal or surpass such works as the Sweetwater Dam, or the Croton Aqueduct, when it came to designing or detailing the every day, average structure of moderate cost, especially with the inadequate funds generally available, in all the realm of engineering literature there was scarcely a word for his guidance.

After laying out a large proportion of the Pacific Slope in town lots, it fell to him to design and detail a number of short span bridges of the type known as "Combination Bridges," with steel tension and timber compression members.

Nothing was to be found in the books and similar existing structures were so evidently inadequate to carry probable loads and so poorly detailed that he was forced to evolve satisfactory plans and managed to produce his first crop of gray hairs at the same time. He confesses to a feeling of some pride that the resulting structures were

simple in detail, provided for all stresses, have been widely copied, and have stood the test of a quarter of a century's use and are still in good condition.

He has since learned that many, and probably the majority of the problems which present themselves to the average engineer, have to do with similar inconspicuous work and has come to believe that in producing good results with often insufficient funds, there is as much or more good engineering perpetrated as in the monumental and spectacular structures so fully covered by the technical press.

The writer's greatest troubles occurred more than twenty years ago and since that time, notably within the past five or six years, there has been quite a change and

It was a four story brick building with basement and sub-basement—the floors and interior columns being of timber.

On account of a fire about 1906, the two upper stories were rebuilt, but the lower stories, basement and sub-basement remained as originally constructed, except for some slight repairs, until August, 1919.

The building was generally "mill construction" but the posts of the basement story extended through the floor to 18 by 36 ins. limestone piers in the sub-basement. On these same piers rested 12x14-in. beams supporting the basement floor joists which were 3x14 ins., spaced 12 ins. on centers. Outside dimensions of the building are 58x140 ft. and there are two rows of nine posts each—the

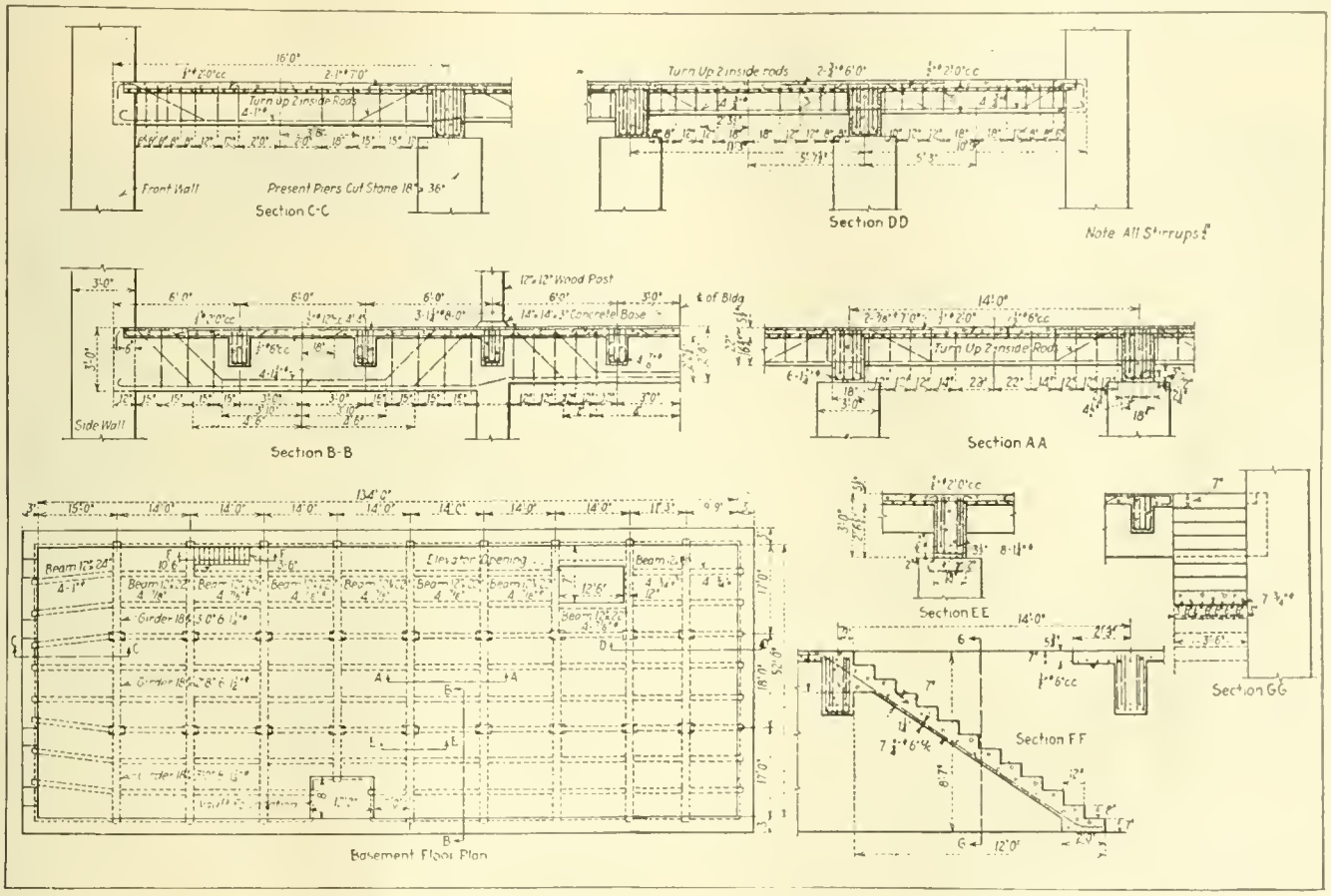


FIG. 1. GENERAL DRAWING SHOWING DETAILS OF A NEW CONCRETE FLOOR PLACED IN AN OLD MINNEAPOLIS BRICK AND TIMBER BUILDING.

today, engineering periodicals and text books contain articles having to do with all kinds of structures, methods of construction, improved details and all the matters of interest to the young engineer and to his older brother in current practice.

New Concrete Floor in an Old Building

In view of his early experience, the writer is impelled to give here, a description of one of the problems which recently presented itself to his office, its solution and the every day ingenious method which lead to its successful conclusion at reasonable cost.

Some twenty-five years ago, there was built in what was then the heart of the business district of Minneapolis, a general store building, and at that time, it must have loomed large.

span of the 12x14 in. beam except at ends, being 14 ft., and of joists, generally 18 ft.

The general arrangement of piers is shown on the Basement Floor Plan—Fig. 1.

In March, 1919, we received a communication from the agent in charge of the building, saying that they were troubled by water in the sub-basement, and while the sub-basement was not used, the tenants objected to the condition and feared it was causing decay as the building showed some settlement, and requested us to investigate and see what could be done to drain and ventilate and what repairs might be needed.

Investigation showed the sub-basement to be some five feet below the street sewer and that during storms, water ran under the floor and down the elevator shaft.

Also, that there was some seepage through the bare limestone stratum in the bottom of the sub-basement.

At the time of the first visit, there was about a foot of water in the sub-basement and it was reported that occasionally, after a rain, it rose to about two feet.

Waste lumber, wreckage of old floor and other debris was scattered and piled about to such an extent that close inspection was practically impossible. It was evident however, that the whole basement floor and a number of the posts were in very bad condition.

There was an old sump at one end of the sub-basement, directly over which was located the main sewer outlet from the building. The first step was the installation there of a No. 3 Pemberthy Cellar Drain, at an expense of slightly over one hundred dollars, after which, to the surprise of the agent and tenants, there was practically no further trouble with water in the cellar.

Old Structure Unsafe

Close inspection now showed a serious condition. Floor joists and beams alike, were rotted to an extent almost unbelievable, in view of the fact that the floor was still standing. Several of the beams were actually broken and apparently held up by the flooring. A number of the posts showed excessive rot below the basement floor line and had settled from 2 to 4 ins. A year or two ago, what the agent spoke of as some permanent repairs had been made by a contractor. A number of the posts had been reinforced (?) by bolting two 12-in. channels about 5 ft. long, to each; 8x8-in. posts on small concrete pedestals had been placed under the centers of a number of the floor beams and a few of the floor joists had been renewed.

The agent was advised to have a new floor built and such posts as showed decay renewed, and as the building was really in a critical condition, such repairs and renewal should be made without delay.

The foundation walls and piers were in excellent condition and plans for a reinforced concrete floor as shown in detail in Fig. 1, were prepared. However, notwithstanding the serious condition, the work was not finally authorized and contract entered into, until late in August, and in the meantime, the prices of labor and material had advanced to such an extent that the contract price was considerably in excess of the first estimate.

During the progress of the work, the tenants, agent and workmen were badly frightened, and the urgent recommendation for immediate repairs justified, as between Saturday night and Monday morning, a section of the building settled nearly three inches. This was not brought about by any operations of the contractor but occurred at a point in the building not yet approached by his work, and was the result of crushing the bearing ends of several of what appeared to be the most nearly sound of the posts.

Fig. 2 is a photograph of lower ends of three of these posts. The chunks on top are what remained of the oak bearing blocks, in relative position to the posts, after settlement, and show clearly the extent to which the posts crushed and settled. Surfaces of posts broke off and cracks formed as shown, when the settlement occurred.

In addition to construction of the concrete floor, the contract provided for jacking the building up to original level and supplying such new posts as might be required. It was found that all posts were badly decayed at the heart and it was necessary to renew them all.

Interesting Feature of the Work

It was assumed that it would be necessary to timber from the sub-basement through the basement floor to the first floor to accomplish this purpose, but the contractor evolved a method which avoided the necessity of doing so, and which was the interesting feature of the work, resulting in a saving of about two thousand dollars.

He, with the approval of the engineers, after removing the old floor, built around each post, as shown by Fig. 3, a sheet metal box, 14 ins. square with one side sloping an inch wider to the top. This slope was just sufficient to permit the posts to be tilted over subsequently and removed.

The ends of the girders and cross beams were enlarged as shown and the reinforcing bars bent over and passed outside the posts.

FIG. 2. VIEW OF DECAYED POSTS REMOVED FROM A MINNEAPOLIS BUILDING.

The floor was cast in three sections and at the time the first section was cast, 18 blocks were cast, 13 ins. square and a little over 3 ft. long to be used as pedestals for the new posts.

As soon as slab was well set, the upper floors at each post were jacked up, old post and sheet metal form removed, concrete block placed and grouted in, and new post put in place. Upper floors were supported and raised by four housemover's jacks at each post supported by 8x8 in. posts on sills resting directly on the new slab. The temporary supports were removed at the end of about 48 hours so that only three sets of posts and jacks were required.

The order of procedure was devised by Mr. Paul Pruffert of the contracting firm of Pike and Cook.

The cost of the work was very close to nine thousand dollars and the net result—a building practically permanent to the first story, good for many years to come, and of which the rental value has been practically doubled.

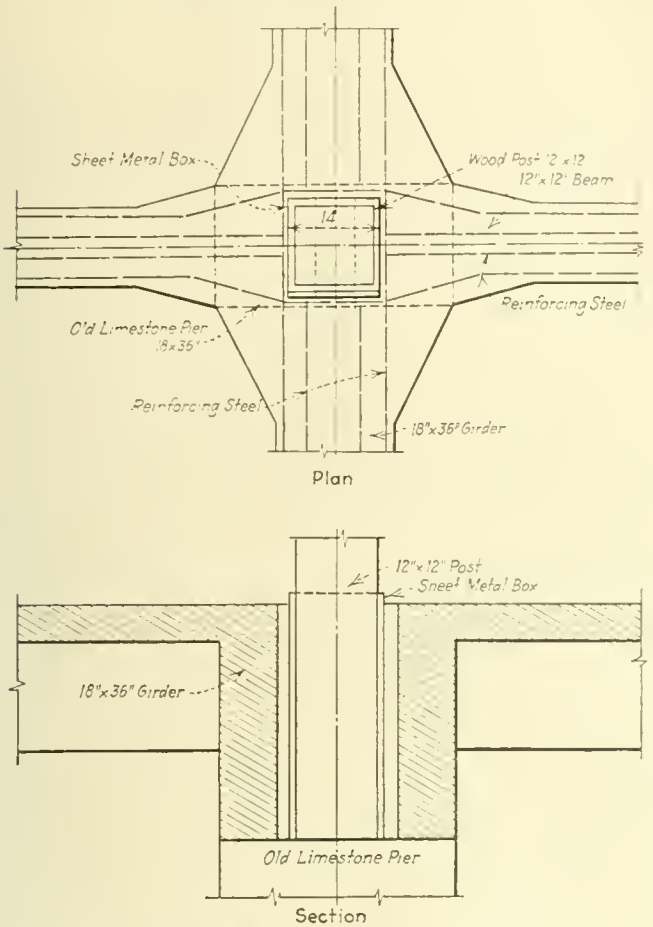


FIG. 3. METHOD EMPLOYED IN REMOVING AND RENEWING THE WOODEN POSTS.

It may be asked why a concrete floor should be placed in a building of this character. The building is used, and practically always has been used, as a wholesale hardware store. Estimates of an adequate timber floor at present prices, were considerably higher than for concrete.

USE OF EXPLOSIVES ON ROAD GRADING

By M. C. Potter, Bellevue, Iowa.

Road supervisors and county engineers in this locality are becoming convinced that it pays to blast down high banks along highways with dynamite in preference to employing old style pick and shovel methods or rooters drawn by teams.

In most all cases, stumps are encountered on top of the banks and gravel or small boulders, are interspersed through them. The boulders and the roots make it difficult and often impossible for the teams to pull the rooters and the breaking of machinery or harness and the injury of the horses is of frequent occurrence.

We have found that by putting down holes vertically in the top of the banks, locating them 3 to 5 ft. back from the face and loading them with a few cartridges of dynamite, the size of the charge depending upon the depth of holes and distance back from the face, much time and labor is saved. Neither stumps, rocks, nor gravel impede the action of the dynamite. The banks are thrown down into the roadway in loosened condition to be loaded on the wagons and hauled away, or in shape to be drawn away in scrapers and used for fills.

I have actually known of cases where dynamite has thrown down as much dirt as a result of 20 minutes' work putting down and loading holes as teams and rooters could remove in a day and at a cost much less than team and labor hire. Even when a steam shovel is used, we have found it to be economical to use dynamite in loosening banks because the steam shovels are enabled to operate much faster on the loosened soil.

TERMS USED IN CONNECTION WITH ASPHALT FOR HIGHWAY WORK

(Editor's Note:—The following definitions of terms used in connection with asphalt for highway work, with explanatory comment, is a reproduction, made by permission, of Brochure No. 5 recently issued by The Asphalt Association. We believe this discussion of terms is especially helpful and are glad to place it on record in a form ready available to our readers. The various brochures issued by the association are of great interest to engineers and other public officials and to all interested in paving work).

Some confusion exists in the popular mind, and to some extent among highway engineers, in connection with terms relating to highway work in which asphalt is used. To many, asphalt has always been surrounded with a certain sort of mystery that has been heightened rather than clarified by various scientific or highly technical reports which have been published from time to time. The purpose of this brochure is to set forth in plain language the meaning of certain terms and to explain their relationship to other terms in order to prevent their inadvertent misuse. In general, involved technical definitions will not be discussed although a number of such have been widely adopted as standard.

The Terms Bitumen and Asphalt

The word bitumen was at one time applied only to certain naturally occurring materials of more or less solid consistency which were black and sticky, and which were usually associated with rock or clay deposits. In connection with highway work this term now includes that portion of petroleum asphalt and tar products, whether crude or refined, which is soluble in a liquid chemical substance known as carbon disulphide. The term bituminous material is even broader in its scope and is applied both to bitumen and materials containing bitumen. The amount of bitumen in a bituminous material, as determined by its solubility in carbon disulphide, is frequently reported as total bitumen in connection with laboratory tests.

Asphalt is a semi-solid or solid sticky product formed

by the partial evaporation or distillation of certain petroleums. If the asphalt has been produced by natural agencies it is called native asphalt and often occurs mixed with considerable quantities of water, gas, vegetable matter and earth or clay. If, on the other hand, the asphalt is directly manufactured from petroleum, it is sometimes called petroleum asphalt and is practically pure bitumen. When asphalt occurs impregnating a porous rock such as sandstone or limestone, it is called rock asphalt. This material contains only a limited amount of bitumen and is mostly rock.

Terms Relating to the Preparation of Asphalt

The term asphalt cement, ("A. C.") is applied to an asphalt which is of suitable consistency for direct use in highway work. If the asphalt is too hard for direct use but is otherwise suitable it is called refined asphalt ("R. A."). When an asphalt is manufactured from petroleum it is usually made directly into an A. C., although it may, if desired, be turned out as R. A. Crude native asphalt is almost invariably subjected to a refining process in order to remove the vegetable and mineral impurities as completely as possible. The refined product is then an R. A. which may still contain an appreciable amount of impurities. Before use in highway work all R. A., whether produced from native asphalt or directly from petroleum, must be softened to suitable consistency by combining it with a flux. Flux or flux oil is a non-volatile liquid produced from petroleum by distilling off the lighter and more volatile constituents. It may be mixed with melted R. A. in proper proportions to form an absolutely homogeneous fluxed asphalt or A. C. of any desired consistency. The fluxing process is usually conducted at a paving plant in the manufacture of paving compositions.

Sometimes an A. C. of suitable consistency for a given purpose is thinned to fluid consistency with a volatile petroleum distillate such as gasoline. The resulting product is then called cut-back asphalt and upon exposure will rapidly become an A. C. through evaporation of the light solvent. An A. C. may also be thinned to fluid consistency by the addition of water provided an emulsifying agent such as soap is present in the mixture. When combined with water in this manner the product is called emulsified asphalt. The term liquid asphalt is sometimes applied to a fluid petroleum product or road oil which is highly asphaltic in character and possesses the property of adhesiveness or stickiness to a marked degree. An asphaltic petroleum is one which contains a considerable amount of asphalt dissolved in the lighter oils present and from which asphalt may be readily manufactured by evaporation or distillation to remove these light oils. Certain asphaltic petroleums are quite similar to cut-back asphalt, in which case they are sometimes called malthas.

Terms Relating to the Physical Properties of Asphalts

The hardness of an asphalt is expressed as penetration, which is a measure of the depth to which a standard needle will penetrate it at a standard temperature during a definite period of time when the needle is loaded with a known weight. Unless otherwise indicated, the temperature, weight and time factors are understood to be 25 deg. Centigrade (77 deg. Fahrenheit), 50 grams, 5 seconds. The depth of penetration is expressed in units. Thus a 50 penetration asphalt is one in which the standard needle penetrates to a depth of 50 units. Asphalt of 100 penetration is a softer grade because under the same conditions of test the needle will penetrate it for a depth of 100 units. Thus the softer the asphalt the higher its penetration, and the harder the asphalt the lower its penetration becomes.

The ductility of an asphalt is expressed as a measure of the distance which a standard briquet of the asphalt will stretch without breaking, at a standard temperature, when the ends of the briquet are pulled apart at a definite rate of speed. The temperature is usually specified as 25 deg. Centigrade (77 deg. Fahrenheit) and the rate of speed is 5 centimeters per minute. Ductility is then expressed as the maximum number of centimeters which the test specimen will stretch without breaking. Thus a ductility of 40 means that the briquet will not break until pulled apart for a distance of 40 centimeters.

The melting point of an asphalt is that temperature at which it softens sufficiently to flow as determined by an arbitrary method. Upon being subjected to a rising temperature there is no critical point at which asphalt suddenly changes from a solid to a liquid, as it gradually becomes softer and softer. The melting point test is ordinarily made by first moulding the asphalt in a circular brass ring which is suspended under water beside a thermometer. A standard steel ball is placed upon the upper surface of the test specimen and the temperature of the test specimen and the temperature of the water is then raised at a standard rate. The temperature at which the steel ball forces the asphalt 1 in. below the brass ring is expressed as the melting point. Other methods have also been devised which, for identically the same asphalt, will show a different melting point. It is therefore important that the exact method of testing be known in connection with any statement of the melting point of an asphalt.

The flash point of an asphalt is that temperature at which it evolves vapors which ignite upon contact with a flame. This temperature is and should be higher than any to which the asphalt should be heated during its application in highway work.

The loss by volatilization of an asphalt is the per cent. by weight which it loses when a sample is heated and maintained at a temperature of 163 deg. Centigrade (325 deg. Fahrenheit) for a period of 5 hours under standard conditions of test.

Pavements and Foundations

Highways in which asphalt is used are almost invariably composed of two or more courses. The upper or wearing course is called the pavement provided it has a substantial thickness, usually of one or more inches. When asphalt is used in the superficial treatment of any pavements to produce, with a subsequent application of stone chips, sand, etc., a thin blanket course, such superficial course is called an asphalt carpet or asphalt seal coat.

The bottom course of a highway which is laid directly upon the subgrade, is ordinarily called the foundation or base and if courses are placed between the foundation and pavement they are called intermediate courses. When

subgrade conditions are particularly bad a course is sometimes placed below what would ordinarily be considered the foundation, in which case it is termed a sub-base.

Asphalt pavements are laid upon a variety of foundations or intermediate courses which may or may not be of the same type as the pavement proper. The most common types of foundation are the broken stone or macadam foundation, the Telford foundation, the cement concrete foundation, and the bituminous concrete foundation. Asphalt pavements are frequently laid upon old pavements such as macadam, cement concrete, brick or stone block, in which case the old highway structure as it exists is usually referred to as foundation.

Classes of Asphalt Pavements

The asphalt Macadam pavement is a broken stone pavement laid in a manner similar to ordinary Macadam, except that the broken stone of the wearing course is coated and filled with asphalt applied by the pouring or penetration method after the stone has been placed on the road. Such application may be made with hand pouring pots or by mechanical pressure distributors. No Macadam pavement which has merely been surface treated with asphaltic road oil, cut-back asphalt, or asphalt emulsion should be called an asphalt Macadam. Such indiscriminate use of the term is not only misleading but places a relatively high and permanent type of construction in the same class with waterbound Macadam which is temporarily maintained by surface treatment.

An asphaltic concrete pavement is one composed of a mixture of asphalt with broken stone, broken slag, or gravel and often with sand and mineral filler as well. The term concrete presupposes a mechanical mixture prepared before laying. When the aggregate of asphaltic concrete is composed of a single commercial size of broken stone such as used in the wearing course of Macadam, the resulting pavement has sometimes been erroneously referred to as asphalt Macadam. Such practice should be discouraged as the asphalt Macadam is always constructed by the penetration method. There are a number of patented pavements belonging to the asphaltic concrete class, such as "Bitulithic," "Warrenite," "Bitoslag," "Ameisite," "Filbertine," etc. An unpatented pavement, known as the "Topeka" type, is an asphaltic concrete in which the individual particles of the mineral aggregate range in size from one-half in. in diameter to dust.

The asphalt block pavement is one constructed of blocks composed of a dense asphaltic concrete which has been subjected to heavy compression during the process of moulding. Such blocks are laid in regular courses as in the case of a brick pavement.

The sheet-asphalt pavement is composed of a mechanical mixture of asphalt with a carefully graded sand and a mineral filler such as limestone dust. The mixture is often called sheet-asphalt topping or surface mixture, and is usually laid on an intermediate course of asphaltic concrete known as the binder or binder course. In some localities asphalt is mixed with local sand which does not meet the standard grading requirements for sheet-asphalt. A pavement constructed of such a mixture is greatly inferior to sheet-asphalt and is usually called an asphalt sand pavement.

A rock asphalt pavement is one in which the wearing course is constructed of natural rock asphalt which is usually crushed or pulverized first and in which is sometimes incorporated additional asphalt or flux oil.

An asphalt-earth pavement is one composed of a mechanical mixture of asphalt with finely divided earthy material such as clay. The "National Pavement," which is patented, belongs to this class.

The term asphalt seal coat is often employed in connection with the use of asphalt in the surface treatment of asphalt Macadam and certain asphaltic concrete pavements, either during or after construction. In such cases the asphalt serves to fill the surface voids in the pavement and when covered with stone chips, fine gravel or sand produces an asphalt carpet or mat which protects the underlying pavement.

Asphalt Fillers

Asphalt fillers are prepared for filling joints and cracks in brick, stone block and cement concrete pavements. There are three general types of asphalt filler.

The poured joint filler is a specially prepared asphalt which may be heated and poured into joints or cracks.

The asphalt-grout filler is a mechanical mixture of asphalt and fine sand which while hot may be poured over the pavement surface and broomed or squeegeed into the joints.

The prepared joint filler may consist either of specially prepared asphalt in the form of premoulded strips, which are inserted in the joints, or they may be premoulded mixtures of asphalt with such substances as limestone dust, silica or shoddy dust. Sometimes the filler strips are reinforced with fabric and sometimes they consist of one or more layers of fabric or felt saturated with asphalt. Premoulded expansion joints reinforced or armored with metal are also manufactured.

Distinction Between Asphalts and Tars

Asphalts are quite different from tars, both in their physical and chemical properties. This fact should be clearly understood in order to prevent confusion in the common use of the word bituminous, which is applied to pavements and products which may contain either asphalt or tar. Thus a bituminous macadam pavement may be either an asphalt macadam or a tar macadam and a bituminous filler may be either an asphalt filler or a tar filler. Therefore, whenever it is desired to identify a product or pavement with the material used, the term bituminous should be replaced with the term asphalt or tar as the case may be.

STREET CLEANING, REFUSE DISPOSAL AND SNOW REMOVAL IN BUFFALO, N. Y.

By George H. Norton, City Engineer, Buffalo, N. Y.

Street Cleaning

In street cleaning in Buffalo for many years the old horse brooms had been used preceded by an attempt at sprinkling. A few years ago the condition was reached where the equipment of the contractor was obsolete. A renewal of the contract did not seem desirable.

Three appraisers were named by the Council, with consent of contractor, to appraise the whole plant, which consisted mainly of horses, mules, broom sweepers, wagons, sleighs, horse equipment and leased barns.

After some adjustments the prices of the appraisers were opposed and the plant taken over by the city. At the same time similar action was taken on the plant of contractor for garbage collection. With these two plants the city found itself possessed of a large assortment of junk located at seven different barns or yards. As fast as possible these were consolidated into two locations; old horses replaced by good ones, repair shops located and the old rolling stock repaired. This was a slowly continued process of improvement until motorization became commercially and mechanically advisable.

Motor Flushers

The first step was in the purchase of flusher equipment for street cleaning. It was evident that no half way measures in equipment would be wise.

A beginning was made with three Pierce-Arrow motor tractors, each drawing a 2,000 gal. tank flusher trailer, having two wheels in rear and front carried on the tractor. These were furnished by the Hvaas Co. With these in use it was at once apparent that a proper and economical method of street cleaning had been reached. Three more were added and then nine more, making the present fleet of 15. The results both as to cleanliness and cost are excellent. The one improvement which yet seems desirable is a successful scraper and pick-up machine. Hand brooming or sweeping is not in line with today's requirements. It would appear that some device of the squeegee kind with pick-up would add materially to satisfactory street cleaning.

The effect of flushing material into sewers through inlets seems to be so dependent upon grades and crowns of pavements, width of street, and frequency of cleaning, as well as kind and size of sewers, that nothing definite can be said as generally applicable.

The above mentioned combination of tractor and flusher seems most appropriate in this Northern city. Flushing cannot well be done in freezing weather. But upon the advent of the freezing weather the quantity of coal and ashes is greatly increased and snow removal becomes necessary. This separable arrangement of tractor and flusher is then economical. The flusher is housed and the tractor augments the hauling equipment when most needed.

Snow Removal

In this Northern city during a normal snow season the auto traffic is forced onto the car track streets unless regular snow removal is maintained on other streets. A few years ago this was of little moment; today it is vital.

With the large fleet of tractors it will now be possible to fight a snow storm from its beginning and keep all thoroughfares open. The feature of elasticity seems to make this combination the most desirable.

Refuse Disposal

In refuse disposal this city has also been guided by results obtained through step by step experience. For many years the public dump was economical. City growth with less available dumps and longer hauls made another method desirable. When the collection was made by contract an arrangement was made with the contractor to build a destructor plant for refuse in city property with right of city to acquire at expiration of contract at 60 per cent. of cost, but before expiration of contract the city took it over at an agreed price.

The old "Morse-Boulzer" furnace was replaced by two "Henan-Froude" furnaces.

All rubbish is assorted and the salable reclamation sold. Many figures might be given but such are so dependent upon market conditions that such would be of little general value. The city fortunately had a good market for its recovered paper, and with such, over a long term of years, this plant has proven just about self-supporting. The quantity of recoverable material has been greatly affected by war conditions and market prices have been variable. The general average of self-support, however, is most satisfactory as it solves the question of dumps and long hauls.

Garbage disposal has been the most troublesome and unsatisfactory. Under the old contract system the collection and disposal was done by a fertilizer company, the garbage being taken to their plant for reduction.

For some reason this reduction seemed less and less desirable even after the city made collection and delivery of garbage and a material price demanded to accept delivered garbage.

The increasing success of hog feeding has been closely followed and in 1919 bids were requested for both reduction and feeding. The first proposals eliminated reduction but so complicated the feeding that new bids were received and contract made on basis of top price of hogs in Chicago on monthly averages and amount of garbage delivered:

6 times for 25,000 tons per year
7 times for 30,000 tons per year
8 times for 40,000 tons per year

While this contract is but recent, it promises a reasonable solution of the garbage problem. Haulage is yet to be settled. The separable tractors used for flushing assist materially. Small trucks have been tried but with small success. Several patterns of trailers are now being tried as to comparative merits.

This brief outline has been given as perhaps typical of a city's experience. Figures in detail from one locality may prove most misleading at another unless the conditions are quite parallel and this is seldom the case.

Sound judgment, a knowledge of the difficulties of other cities, courage and opportunity for reasonable trial of new methods seem the essentials for reasonable progress in the "housekeeping of cities."

The foregoing matter is the major portion of the report of the Committee of the American Society for Municipal Improvements of which Mr. Norton was chairman.

GARBAGE DISPOSAL AND THE ECONOMIC RECOVERY OF VALUABLE CONSTITUENTS OF MUNICIPAL WASTE

By Samuel A. Greeley, Hydraulic and Sanitary Engineer 39 W. Adams St., Chicago, Ill.

The subject matter of this paper covers a large and important field of municipal activity. It is not within its scope to reach many of the details of the processes re-

quired for the economic recovery of valuable materials from municipal refuse and the paper deals very largely with general principles and the limitations attending their application.

The term "Valuable" is, furthermore, difficult to use with any degree of certainty under present market conditions. Only the most careful consideration of local are good after 12 years' service. The majority of walkbility can justify definite conclusions. The author has therefore undertaken this task with much hesitation.

Particular attention is directed to the importance of local conditions in developing methods of garbage disposal.

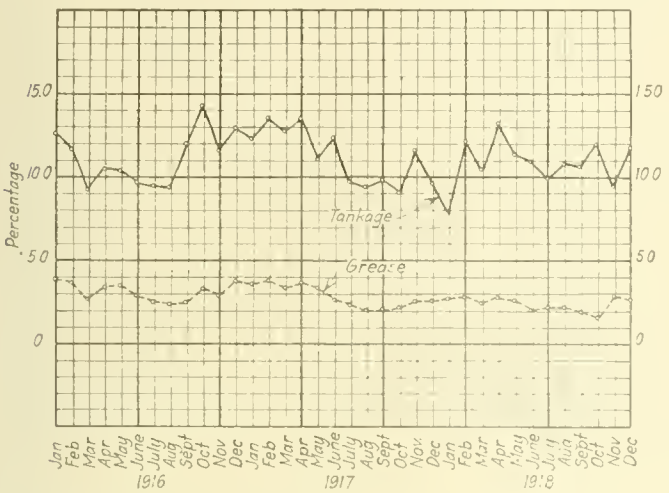

Percentage
150
100
50
0
Tankage
Grease
Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec
1916
1917
1918

FIG. 1. MONTHLY PERCENTAGE RECOVERY OF GREASE AND TANKAGE AT CLEVELAND REDUCTION PLANT 1916-1918.

another by reduction, etc. Matters of administration, stage of city development, past experience and training in garbage disposal, location, climate, character of population, topography, soil and many other factors are pertinent.

Fundamental Considerations

Broadly speaking a method of final disposal of municipal refuse should serve three functions as follows:

(a) It should render satisfactory service to householders.

(b) It should be measurably clean and sanitary.

(c) It should be reasonably economical.

In accomplishing these three ends, there are four parts or phases of the problem to be developed as follows:

(a) The House Treatment.

(b) The Collection.

(c) The Transportation.

(d) The Final Disposal.

The problem of garbage disposal is the proper development and adjustment of these parts of the problem to local conditions. The house treatment more directly affects the people; the collection is generally the more costly part of the work; transportation other than in collection wagons is needed only in the larger communities; while final disposal involves more engineering work and in general stimulates more discussion than the others. In the author's opinion, each of the four phases is equally important and a limitation of what follows primarily to disposal is not intended to eliminate or discard the influence of house treatment, and collection upon the disposal.

Two other fundamental considerations are important viz. (a) the so-called relative values in sanitation and (b) the fact that a successful handling of the refuse problem revolves primarily about operation. By relative values is meant such items as, for instance, the stage of other municipal improvements possibly more directly affecting the public health as well as the question of the proper cost of measures for eliminating odors not constituting a general nuisance. It is also obvious that "Operation" looms large in refuse disposal work and must be given first consideration during the development of new works.

Valuable Constituents

Refuse is the term for the solid waste resulting from community activities as distinguished from sewage. Refuse is made up of garbage, ashes, rubbish, manure, and many other materials. The valuable constituents contained in them are as many as the varied activities of the community. These constituents may, however, be roughly classified by the methods (of disposal) used to recover them thus:

(a) Dumping or land fill makes the fullest use of the inert constituents of refuse not otherwise generally useful. Sometimes valuable land can thus be made.

(b) Burial or ploughing into the soil makes possible the recovery of those constituents of refuse which are valuable for fertilizing the soil. Manure is quite generally disposed of in this way and some cities have developed its collection and transportation to farming districts very advantageously to the public comfort and the municipal

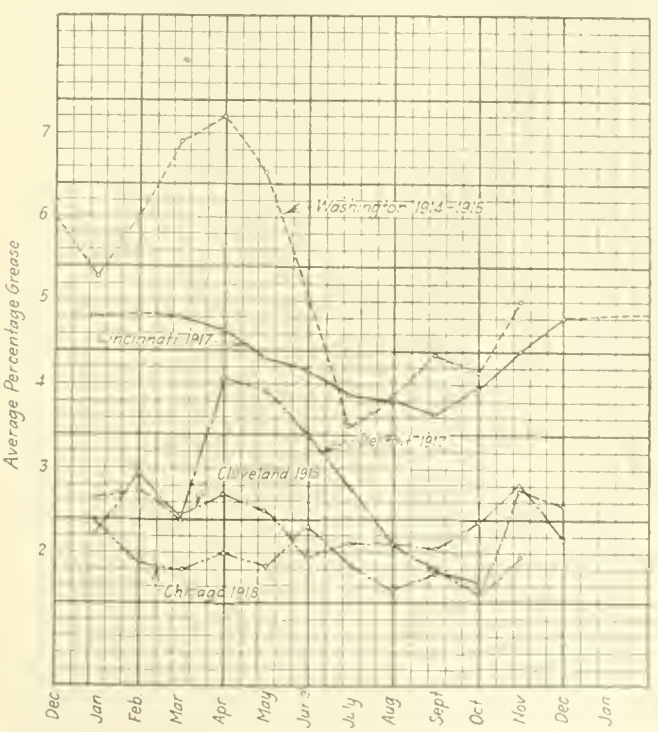


FIG. 2. MONTHLY PERCENTAGE RECOVERY OF GREASE AT VARIOUS GARBAGE REDUCTION PLANTS.

pocketbook. At Columbus, Ohio, a gross revenue of about $4,000 per year is derived from the sale of manure. Street sweepings are also used in this way, sometimes, for instance, to cover dumps of mixed refuse for park purposes.

(c) Mixed refuse can be burned at high temperature

with the production of steam suitable for power development, thus recovering or using the carbon and hydrogen contained in the refuse. With the increased demand for power, the higher price of coal and oil, and the gradual reduction in available close-by dumping areas, the value of refuse for steam production is increasing.

(d) Garbage contains grease and tankage, both valuable constituents which are being economically recovered on a large scale by the reduction process.

(e) From rubbish many marketable materials can be recovered, such as paper, rags, leather, old metals and the like. The process is commonly termed rubbish sorting.

(f) An old and universal method of recovering the valuable food constituents from garbage is by feeding to hogs. This is one of the most interesting and useful methods of garbage disposal which has recently been given much prominence by the war shortage of food.

(g) There are many other processes for the recovery of valuable constituents from garbage which have been more recently studied, such as the production of alcohol and the preparation of a stock and chicken food.

Some of the more generally used of these methods of recovery are commented on in the following sections:

Hog Feeding

For garbage alone, feeding to hogs is a method of disposal which undoubtedly has a wide field. By this method the food constituents of garbage are recovered in part. During some tests during an investigation of the refuse disposal problem made by the writer in Louisville, Ky., it was found that 32.4 lbs. of city garbage were required to add 1 lb. to the weight of the hogs. The tests lasted seven weeks and covered observations on the feeding and growth of 25 to 40 hogs. The garbage was taken from several collection districts, but contained a somewhat smaller amount of other refuse materials than much city garbage. With pork on the hoof at 15 cts. a pound, the garbage would have a gross value of $9.26 per ton. It was actually sold by the city at this time (September, 1918) at $3 to $3.50 per ton for feeding to hogs.

At Worcester, Mass., where the separation of garbage is very good, it takes 37.5 lbs. of garbage per pound gained by the hogs.

Hotel garbage has a higher food value. Mr. Gaumnitz, who feeds much hotel garbage in St. Louis, states that it takes 25 lbs. of garbage to make 1 lb. of gain on a hog; and this data is confirmed by tests at the Iowa Agricultural Experiment Station. At 15 cts. per pound of pork, hotel garbage would thus have a gross value for feeding purposes of $12 per ton.

From the gross indicated value of garbage for hog feeding it is, of course, necessary to deduct plant operation, risk, overhead, fixed charges, etc. These vary with the location of the hog farm, the value of the land, the climate, the length of the contract and the care with which the operation of the farm is conducted. In 1916, in connection with a study of garbage disposal in Worcester, Mass., the writer estimated the total annual cost at $2.30 per ton, which was considered rather liberal at that time, but was predicated on an ample plant and good operation. As a matter of fact contractors seem willing to pay not much over $1 per ton for city garbage, and in some cases less, some contract prices being as follows:

Town	Year	Price paid by Contractor to City per ton of delivered garbage
Minneapolis, Minn.	1918	$1.26
Grand Rapids, Mich.	1917	.45
Portland, Ore.	1918	3.90
Newark, N. J.	1919	1.20*
St. Paul, Minn.	1917	.80
South Bend, Ind.	....	....
Anderson, Ind.	1917	1.00

Note *: Figured at 8 times the price of live pork in Chicago.

Metals—

The operation of hog farms is not an easy matter and varies considerably in different places, which may possibly explain the abandonment of hog feeding as a method of disposal in some cities. Of first importance is a superintendent who knows the feeding and care of hogs. But sanitary considerations are likewise important and must supplement the experience of the hog feeder. The more important items are:

(a) Methods of feeding. (b) Area required. (c) Pens and runways. (d) Vaccination. (e) Disposal of unconsumed garbage. (f) Suppression of rats and flies.

The design will depend somewhat upon the location of the hog farm. For instance, in a report on hog feeding of garbage at Rockford, Ill., the writer recommended that "No garbage be fed to hogs in buildings closer than 300 ft. from a traveled roadway, and that garbage fed out of doors on platforms should be at least 600 ft. away." Of paramount importance, however, are matters of house treatment, frequency and adequacy of collection and other items affecting the public comfort and the quality of the garbage.

Incineration

The carbon contained in refuse is a valuable constituent. The carbon content of garbage is low, generally less than 5 per cent., and is not sufficient to warrant economical recovery. However, the carbon content of ashes and rubbish is higher, and so-called "Mixed Refuse" (garbage, ashes and rubbish as collected from houses) contains as much as 20 per cent. of carbon. This gives it a value of about one-fourth that of coal (80 per cent. carbon), and as many municipalities are now paying upwards of $5 per ton for coal in pumping stations and lighting plants, the indicated gross value of a ton of mixed refuse is $1.25. Assuming an average evaporation of 1 lb. of steam from and at 212 deg. F. per pound of refuse, this is equivalent to 6¼ cts. value per 100 lbs. of steam as compared with 4 cts. per 100 lbs. of steam used in the Milwaukee incineration tests in 1910.

A plant to burn mixed refuse should be especially designed for that purpose and should preferably be designed and built from plans and specifications prepared by (or for) the municipality instead of from general plans offered by contractors. Proper combustion without nuisance and longer life are thus likely to be secured. The details of design cannot be taken up in this paper, but there are a number of plants which have been giving good service for periods up to 12 years in this country, as at Savannah, Atlanta, Milwaukee, West New Brighton, Westmount and elsewhere. A record of power production at the Milwaukee refuse incinerator is shown in Table I and a record of operation of the refuse incinerator at Westmount, Canada, in Table II.

In projects for mixed refuse incineration the effect of collecting the refuse mixed on the house treatment and cost of collection are important factors.

TABLE I—POWER PRODUCTION AT REFUSE INCINERATOR, MILWAUKEE, WIS.

Month 1917	Total K.W. Hrs.
January	3,466
February	.....
March	.....
April	59,160
May	32,985
June	32,072
July	86,404
August	118,249
September	107,057
October	59,607
November	16,884
December	.....
	515,794

Notes:

	Average percentage of refuse incinerated
Garbage	68.84
Ashes	26.49
Rubbish	4.49
Manure	0.17

Average evaporation per pound of mixed refuse, 1.626 lbs.
Data from 1917 Ann. Report Dept. of Public Works.

Rubbish Sorting

Rubbish contains much material which can be sorted out and sold, such as paper, rags, metals, rubber, shoes and the like. During the war the government urged that this should be done as a conservation measure, and there appears to be no reason why the practice is not good.

The gross value of rubbish varies with the market over a wide range. From 35 to 50 per cent. of the rubbish by weight can usually be recovered under normal city conditions. These materials bring in a gross revenue of about $2 per ton of rubbish on pre-war prices. The figures from the Columbus municipal rubbish sorting plant are given in Table III. The selling price or rubbish materials in the Chicago market from quotations dated November 7, 1919, are as follows:

Metals—	
Copper	$ 0.16 per pound
Light Copper	.15
Brass, Red	.16
Brass, Heavy Yellow	.10½
Brass, Lighter Yellow	.09
Brass, Yellow Boring	.09
Brass, Red Boring	.14
Lead	.05¼
Zinc	.05
Mixed Iron	12.00 per ton
Rags—	
Mixed Rags	.03 per pound
Bagging	.02
Paper—	
Newspaper	.70 per 100 lbs.
Mixed Paper	.60 per 100 lbs.
Rubber—	
Automobile Tires	.03 per pound
Tubes	.09 per pound
Mixed Boots and Shoes	.07 per pound
Arctic Shoes (cloth covered)	.04 per pound

A rubbish sorting plant comprises a receiving room and a wide belt conveyor traveling slowly up between two platforms on which the sorters stand. Along the outside of each platform are bins for storing the sorted-out material. Below the bins are baling presses and other apparatus used to prepare the materials for shipment. An incinerator, usually with a boiler, is required to burn the unsorted rubbish. Such plants are in operation at Buffalo, Rochester, Pittsburgh, Columbus and elsewhere; and in many places rubbish materials are sorted out on the dump and sold. The revenue from the sale of the sorted-out materials does not usually much more than pay for the cost of operation.

TABLE III—REVENUE FROM MUNICIPAL RUBBISH SORTING PLANT AT COLUMBUS, OHIO.

	1918	1917
Bottles	$ 116.33	$ 365.21
Paper	1,876.06	1,859.06
Iron	58.19	145.53
Rags	239.45	579.94
Cans	1,600.31	452.59
Metal	5.50	114.39
Miscellaneous	28.26	5.03
	$3,924.10	$3,521.75

Reduction of Garbage

Reduction of garbage is a chemical and mechanical process whereby the garbage is separated into four parts, viz., volatile matter driven off as gas, water, grease and a dry material which is somewhat stable, mostly fibrous and of vegetable and animal origin, and is called tankage. The grease and tankage have market values.

The mount of these materials which can be recovered depends upon the character of the garbage and the process used for recovery. Two and one-half per cent. of grease and 11 per cent of tankage by weight of raw garbage may be recovered (see Figs. 1 and 2). The gross value of these constituents depends upon the market price, which varies greatly, as shown in Table IV. The present market price of grease is about 6 cts. and of tankage about $10 per ton, which would indicate a gross value of garbage for the reduction process of $5.10 per ton. During the war these prices were doubled.

Many processes have been devised for reducing garbage, most of which fall into one of three groups, designated as follows:

(a) Drying Method.
(b) Cooking Method.
(c) Cobwell Process.

TABLE IV—VALUE OF PRODUCTS FROM GARBAGE

	Market Price of Grease Cents per Pound			Market Price of Tankage Dollars per Ton		
	Chicago	Cleveland	Columbus	Chicago	Cleveland	Columbus
1913	....	4.26c	3.73c	....	$6.00	$6.79
1914	....	4.17	4.32	....	6.75	7.41
1915	....	4.41	3.76	....	8.75	7.00
1916	7.29c	6.50	5.17	$4.16	7.75	8.50
1917	7.34	8.00	7.50	4.16* 10.27**	9.58	10.84
1918	11.57	13.50	11.76	10.27* 16.85**	18.50	20.50
1919	....	5.0-7 6	....	....	10.00	

Note: * To August 1st. ** Balance of year.

The Cobwell process is the most recent and may be described as the "dehydration or drying of the garbage by cooking at low temperature while immersed in a solvent, the extraction of grease from the dried garbage by the same solvent, the recovery of the solvent for

TABLE II—SHOWING FIXED CHARGES, OPERATING COST AND REVENUE OF WESTMOUNT REFUSE INCINERATOR.

Item	1907 10 months	1908	1909	1910	1911	1912	1913	1914	1915	1916
No. of tons of refuse	10,704	13,641	14,331	15,280	17,008	20,878	18,731	23,800	20,800	19,500
				Cost Per Ton						
Fixed Charges—										
Interest	$0.19	$0.13	$0.19	$0.25	$0.25	$0.21	$0.23	$0.18	$0.20	$0.22
Sinking Fund	0.04	0.08	0.06	0.08	0.07	0.05	0.05	0.04	0.05	0.05
Loss on Bonds, proportion	....	0.01	0.004	0.004	0.004	0.003	0.003	0.002	0.002	0.002
Depreciation	0.13	0.12	0.15	0.21	0.21	0.17	0.17	0.15	0.16	0.17
Operating Charges	0.55	0.52	0.46	0.48	0.59	0.48	0.65	0.55	0.65	0.71
Total Cost	$0.91	$0.89	$0.86	$1.02	$1.12	$0.91	$1.10	$0.92	$1.05	$1.15
Revenue	0.36	0.31	0.40	0.40	0.46	0.40	0.45	0.48	0.48	$0.46
Net Cost	$0.55	$0.58	$0.46	$0.62	$0.56	$0.51	$0.65	$0.44	$0.57	$0.69

TABLE V—MATERIALS RECOVERED AT CLEVELAND AND COLUMBUS REDUCTION PLANTS

Year	Cleveland			Columbus		
	Total tons of garbage reduced	Percentage of total garbage recovered		Total tons of garbage reduced	Percentage of total garbage recovered	
		Grease	Tankage		Grease	Tankage
1905	30,382	2.63				
1906	34,891	3.07				
1907	37,606	3.14				
1908	41,242	3.46	9.2			
1909	44,525	3.70	11.3			
1910*	44,747	3.75	13.2			
1911	46,562	3.53	12.8	17,534	1.85	12.9
1912	43,555	3.38	11.5	18,789	2.72	11.6
1913	52,384	3.13	9.7	20,711	2.72	10.5
1914	55,730	2.95	10.5	21,629	2.73	9.7
1915	66,271	2.81	10.4	22,909	2.21	10.0
1916	63,450	3.06	11.2	21,862	3.08	10.3
1917	56,121	2.73	11.3	17,127	2.26	10.21
1918	57,254	2.36	11.0	15,630	2.16	10.26

* At Columbus operation began in July, 1910, and there was no percolation until January, 1912.

further use, and the production of grease and dry tankage for the market." Almost all of the action takes place in closed reducers and the connections. At New Bedford, Mass., the recovery by the process is stated to be 4 per cent. of grease and 15 per cent. of tankage, and at Los Angeles, Calif., 15.5 per cent. of grease and 3.1 per cent. of tankage.

In the drying method the garbage is first dried and then degreased in naphtha percolators. The grease recovery is comparatively low and the tankage recovery somewhat higher than in other processes. Thus at the Chicago reduction plant, which uses the drying method, the percentage of grease recovered is 2.0 and of tankage 22.7 for the year 1918.

The cooking method comprises a first cooking of the garbage with live steam under pressure, then pressing out the free water and grease, then drying the pressed material and finally recovering additional grease by percolation with a solvent. This process is used at Cleveland, Columbus and elsewhere. The percentage of grease and tankage recovered is shown in Table V. Garbage reduction plants are usually located at some distance from built-up districts which requires a transportation of the garbage. This and other local factors such as size of city should be considered in connection with this method of disposal.

Miscellaneous Methods

There are, in addition to the more generally used methods mentioned above, several comparatively new methods not yet tried out on a very large scale. The Union Poultry Food Company of Los Angeles have a process which consists in placing the garbage as collected in a direct heat steam dryer. The dried product, which amounts to about 18 per cent. by weight of the garbage, is sold for poultry food, bringing as high as $40 per ton. This would indicate a gross value of the garbage of $7.20 per ton. The process has been considered at Kansas City, Mo.

A process for the production of alcohol from garbage under patents held by Dr. S. J. Morgan has been tested (1916) on an experimental basis at Columbus, Ohio. These tests showed a possible yield of 4.8 gals. of alcohol per ton of garbage, which at 40 cts. per gallon indicates a gross value of $1.92 per ton of garbage. It appeared from the tests that the recovery of grease and tankage was not materially affected by the alcohol recovery process.

There are, of course, other processes such as that of Dr. Hirsh, recently considered at St. Louis, which the inventor guarantees will yield "at ordinary market prices" not less than $3.60 per ton of garbage; the "Nufuel" or "Oakoal" process for making fuel briquettes and others. There is not space for further comment.

Summary

The writer does not feel justified in offering any conclusions to this paper except that garbage disposal should be considered with a view, where possible, to an economic recovery of valuable constituents. The lure of profit, however, should not overshadow the development of operation for the convenience and comfort of the householder and for the economy of collection. It is a mistake to arouse public opinion on the matter of disposal where other parts of the problem are of equal importance and sometimes more costly. Nevertheless economy of operation, elimination of waste, the salvage of useful and essential materials are matters of vital importance in the present development of society and the skill and efficiency with which they are done will reflect the general progress of the community. This means that the economic value of valuable constituents of garbage and other refuse materials must be considered with the house treatment and collection, first cost of plant, overhead and fixed charges and costs of operation. When and where the problem is approached in this broad, sound way the writer believes that methods of disposal involving the recovery of valuable constituents will endure and will permit of operation without the interruptions and changes of methods which now occasionally occur.

Acknowledgment

The foregoing paper by Mr. Greeley was presented before the annual convention of the American Society for Municipal Improvements:

PAYMENT FOR PREPARING THE SUBGRADE; HOW ROCHESTER, N. Y., SOLVED THE PROBLEM

By J. O. Preston, C. E., Assistant Engineer, Rochester Bureau of Municipal Research, Inc., Rochester, N. Y.

Bid prices for pavement construction generally are itemized to the extent of being divided on the square yard basis and yet contractors seldom know what the item finally will include. The general practice in 15 of the 33 cities from which data has been collected is to include the work of displacement grading in with the item of pavement foundation, bids being taken only for the latter at a price per square yard. For example, the old specifications for local improvements in Rochester, N. Y., provided,

"In all improvements where pavements (and walks) are laid, all excavation and filling that is necessary to be done must be included in the prices bid for pavement, sidewalks, and other items of work, and will include the removal of all old paving, crosswalks, curbs, etc., that are required to be removed. . . . . such trees (less than 6 ins. in diameter), boulders, or other obstructions as may be in the way of completing the improvement shall be removed from the street by the contractor . . . said price (for pavement or walks) shall include . . . . all the grading, including both excavation and filling necessary to bring the finished surface to the lines, grades

and sections shown on the maps exhibited at the letting or required by the Engineer. . . . ."

Displacement Grading

While the term "displacement grading" means the removal of materials from and the shaping of the cross-section which the pavement displaces, the actual use of the term, as illustrated above, makes it include, practically all volumes of excavation and filling connected with getting the roadway to grade. When the plans called for a very deep cut, under the specifications just quoted, it was sometimes the practice to ask for bids for earth excavation for such cuts but the item was allowed to the contractor only where specifically indicated on the plans.

A Misleading Item

The advantages of using the item of pavement to include grading and miscellaneous excavation and filling are that all areas inside of the street lines are certain to be graded, that the Engineer is not required to take careful or frequent cross-sections and, although an injustice to him, the contractor has small chances of collecting for inaccuracies of earthwork, rock and other items exhibited on the plans and called for in the engineer's estimate. On the other hand, the contractor is at a big disadvantage because he is seldom allowed to take the plans into the field (on municipal work) before making his bid and cannot carefully check the cross-section or quantities if he does manage to get a set of the plans. The cost data based on the bids for this item do not allow fair comparison and moreover the contractor is forced to gamble on the amount of work to be done.

Other factors are involved, such as the fact that accurate quantities help to prevent unbalanced bids, they give the property owners and councilmen real information as to the probable cost of work. The work itself is likely to be delayed because of the engineer being required to ask for authority to exceed the estimate, etc., when the quantities are only approximated.

Units Can Be Too Much Itemized

There is justification in the argument that a separate item for grading, not including displacement excavation and filling, requires too frequent and accurate cross-sections with corresponding lengthy computations in the engineer's or preliminary estimate, in all partial, and on the final estimates. If the work of preparing the subgrade and laying the pavement foundation are made separate items on the bidding sheet, considerable unnecessary work is required unless the definition of the former item is conveniently defined.

When the Rochester Bureau of Municipal Research instigated the complete revision of the engineering specifications for its city, the writer assisted in working out a satisfactory plan wherein frequent and painstakingly accurate cross-sections are not required for minor differences in the crowns of the old roadway and the new pavement surfaces. But the bidders are protected from uncertain excavation and filling quantities.

The New Provisions

In the division of the specifications dealing with the grading of unimproved streets as well as in the part relating to subgrade, prices are required on the item of preparation of the subgrade. The unit is the lineal foot at the width of the right of way for each individual street. The specification for grading unimproved streets provides,

"The cost of grading unimproved streets, as specified . . . . shall be included in the contract price for roadway, sidewalk and gutter grading (grading unimproved streets) and shall include all excavation below a horizontal line drawn between the established grades at the street lines (street width) as shown on the standard plans (see Fig. 1), also the shaping of the roadway and gutters. All excavation above the said horizontal line shall be considered as extra earth excavation and shall be paid for at the contract price for earth excavation.

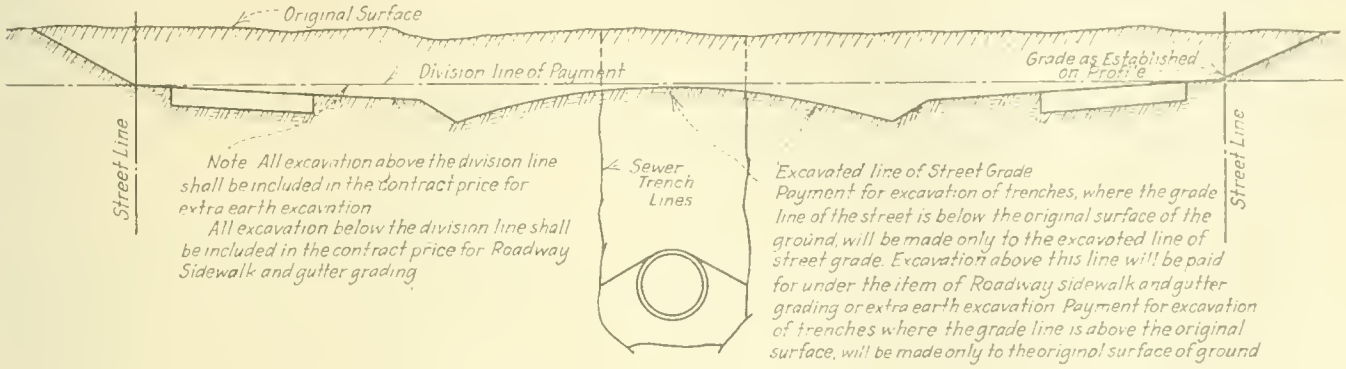

Original Surface
Division line of Payment
Grade as Established on Profile
Street Line
Note All excavation above the division line shall be included in the contract price for extra earth excavation
All excavation below the division line shall be included in the contract price for Roadway Sidewalk and gutter grading
Sewer Trench Lines
Excavated line of Street Grade
Payment for excavation of trenches, where the grade line of the street is below the original surface of the ground, will be made only to the excavated line of street grade. Excavation above this line will be paid for under the item of Roadway sidewalk and gutter grading or extra earth excavation Payment for excavation of trenches where the grade line is above the original surface, will be made only to the original surface of ground
Street Line

FIG. 1. SECTION OF SEWER, WALK AND GRADING.

"If the embankment exceeds the excavation within the limits of the work, then the additional embankment required, except as provided in . . . . . (refers to clause regarding deficiency of filling) . . . . . will be paid for when authorized by the engineer, according to the contract price for earth embankment.

"Payment for excavation of trenches where the grade line of the street is above or below the original surface of the ground will be paid for in accordance with Division D-1, Section b, paragraph 6."

The last mentioned clause is in the division dealing with trenches and it provides in part as follows.

". . . . . payment for excavation of trenches, where the grade of the street is *below* the original surface of the ground, will be made only to the 'excavation line' of the street grade as shown on the standard plans (see Figs. 1 and 2); excavation above the line will be paid for either under the item of 'roadway, sidewalk and gutter grading,' 'preparation of subgrade' or 'extra excavation.'

"Payment for excavation of trenches, where the grade line is *above* the original surface, will be made only to the original surface of the ground. . . . . ."

In the division of the specifications concerning the subgrade for pavements it is provided,

"The cost of preparing the subgrade as specified . . . . . except as otherwise provided, and including all excavation below a horizontal line drawn between the established grades at the street line, as shown in the standard sections (see Fig. 2), shall be included in the contract price for preparation of the subgrade. Excavation above the said horizontal line shall be considered as extra earth excavation and will be paid for at the contract price for earth excavation.

"Payment for excavation of trenches where the grade line of the street is above or below the original surface of the ground will be paid for in accordance with Division D-1, Section b, paragraph 6. . . . . ."

The clause last referred to was quoted four paragraphs above.

The excavation required for curbing is provided for in the division of the specifications relating to setting stone curbing which provides,

tempt to define two horizontal lines limiting the excavation and filling to be included with the item of preparation of the subgrade for pavements. The idea was to make one line level with the top of the curbs and the other on a level with the lowest depth of the bottom of the pavement below it. The fact that for very wide streets the crown of the pavement would project through such a top limiting line, that it is desirable to have the shaping of the area between the walk and the curb included and that the varying thickness of different types of pavements make it impractical to set the lower horizontal line, resulted in the method described. The top horizontal line was set level with the intersection of the sidewalk slope, and the property line (see Figs. 1 and 2) and, when a deficiency of filling exists, the contour of the finished subgrade is taken as the lower boundary.

Summary

The method of paying for all work under the new specifications is based on the principle that to insure all essential details being performed properly, they must be

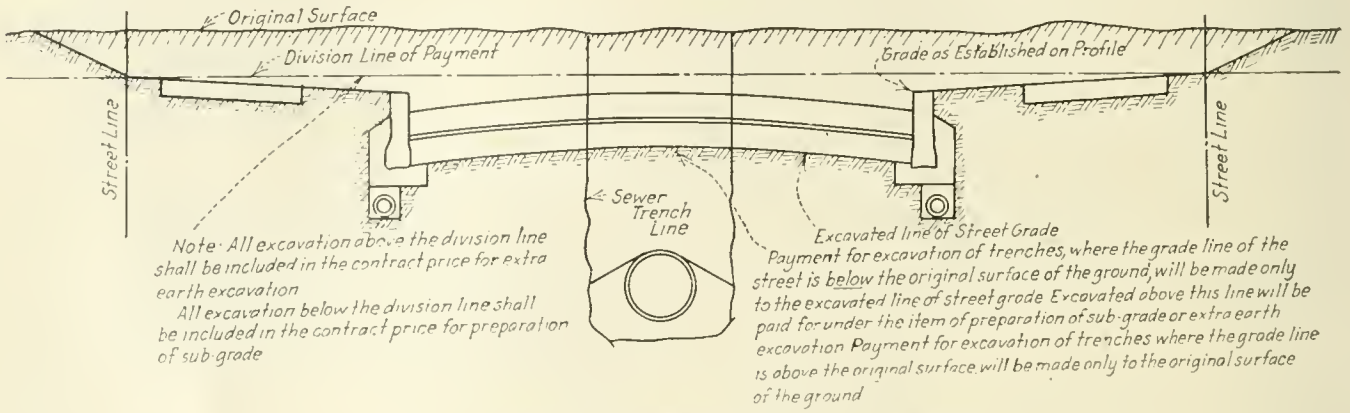

Original Surface
Division Line of Payment
Grade as Established on Profile
Street Line
Street Line
Sewer Trench Line
Note: All excavation above the division line shall be included in the contract price for extra earth excavation
All excavation below the division line shall be included in the contract price for preparation of sub-grade
Excavated line of Street Grade
Payment for excavation of trenches, where the grade line of the street is below the original surface of the ground, will be made only to the excavated line of street grade. Excavated above this line will be paid for under the item of preparation of sub-grade or extra earth excavation. Payment for excavation of trenches where the grade line is above the original surface will be made only to the original surface of the ground

FIG. 2. SECTION OF PAVEMENT, SEWER AND WALK.

". . . . . The cost of excavating for the curb shall be included in the price for the preparation of the subgrade in accordance with Division C-2, page 12, section a, paragraph 8 of these specifications (refers to the clauses quoted four paragraphs above) . . . . ."

Trouble was experienced under the old specifications in getting the pavement contractors to shape the grass plot area between existing walks and the curb but it is evident that the new specifications provide for this work. The new specifications make a separate item and require a bid price for the preparation of the actual subgrade under new walks. The provision relating to this is as follows,

"The cost of preparing the subgrade (for walks) as specified above in . . . . . except as otherwise provided, shall be included in the contract price (per square foot) for the preparation of subgrade for walks . . . . . Where the contracts are for walks only the items for earth excavation shall include all excavation above the finished grade line, as shown on the standard plans, and shall be for such width as indicated by a special section."

The Development of the Clauses

The first effort in preparing the clauses quoted above for the payment for preparing the subgrade was to at-

itemized into convenient units and the contractor paid for them when performed. The inducement to skimp the work or to bid high for safety is thereby removed. The volume of claims for extras is likewise reduced. All items and questionable points are carefully defined, such as the size of boulders for which the item of rock excavation will be allowed, etc.

The bid prices under the new are more susceptible to comparison than were those under the old specifications. The variation in street widths causes slight discrepancy in comparison of prices for grading but the saving in taking of cross-sections, in computations, etc. more than off-sets this slight fault. The allowance for trench excavation requires some computation but the saving which results makes the effort worth it.

The contractors are more satisfied with the new provisions, there being no doubt as to what the item of preparation of subgrade for pavement or walks includes. The city engineers gladly admit that the item is especially helpful because it makes it considerably easier to prepare partial estimates. There is no doubt but that the method of paying for the items is a vast improvement over the virtually lump-sum bid for the items of pavement or walks complete in place as the old specifications required.

Messrs. E. A. Fisher, C. A. Poole and F. A. Delavau of the City Engineering Department were associated with

J. W. Routh and the writer of the Bureau of Municipal Research in preparing the new engineering specifications from which the above quotations are taken.

DEVELOPMENT AND INSPECTION OF SUPPLIES OF MATERIAL FOR HIGHWAY CONSTRUCTION

By Austin B. Fletcher, State Highway Engineer of California, Forum Bldg., Sacramento, Calif.

It is indeed a day of heavy highway programs; we talk as glibly of forty, sixty or an hundred millions of state highway bonds as we did a few years ago of five or ten millions. We talk now of annual programs of highway construction of from ten to twenty-five millions without particular difficulty, said Mr. Fletcher in addressing the annual meeting of the American Association of State Highway Officials.

But talking about such programs is one thing and getting experienced engineers and assistants, finding enough contractors of sufficient ability and financial responsibility and securing the huge quantities of proper materials of construction promptly is quite another story.

Hardly any two states of the Union have the same problem to solve.

In some of the states where state highway activities are of very recent date the troubles with respect to the supply of materials of construction must be acute and hardly any state has been accustomed heretofore to thinking of the supplies in terms of the enormous volumes we are now facing.

The public now in thinking or speaking of a state highway have in mind an expensively paved road. In general it may be said that the days of gravel or waterbound macadam roads are no more.

Using Local Materials

In most of the states the location of the principal supplies of gravel, sand and broken stone is fairly well known, but for extensive paving operations these supplies must be increased greatly and new deposits located if the highway work is to proceed with the dispatch desired by the public.

Often the engineer must decide whether he can or must use materials of somewhat inferior quality or whether materials of better quality can be shipped to the work by rail. These decisions often require nice judgment and no highway department can consider itself well organized without a geologist competent to assist the engineer in such matters nor unless it have a well equipped testing laboratory with trained assistants to operate it.

Railway Failures

In many instances the material supply difficulty is not so much the lack of material as it is the failure of the railroads to ship it promptly and as ordered. In some states it is notorious that the railroads do not have enough suitable cars to give the needed service and this is true particularly at the crop moving periods. Hardly anything will do more to disrupt a highway contract than the failure of the railroad to furnish the materials of construction as they are needed.

This failure of the railroads, unless it can be corrected otherwise, would doubtless, in some states, under the heavy programs, justify the purchase of railroad cars by the state department for highway use.

If the railroad may be depended upon, the economical way of handling the materials, particularly such stuff as broken stone, sand and gravel, is to unload from the cars and place the materials on the road where they are to be used without unnecessary rehandling, which is always a costly performance.

Stockpiling Material at Convenient Points

Failing prompt railroad service, and in these days we rarely expect regular deliveries, one remedy is to stockpile the materials at convenient points. Sometimes, but not often, it is possible to haul the materials and place them in small piles within the right-of-way but more often they have to be placed in large piles near the railroad sidings.

The use of portable derricks or cranes with clamshell buckets lessens to a large extent the rehandling expense but whether machinery is used or not it seems obvious that the materials must be available when the contractor needs them.

It will also be found that because of the extraordinary number of motor trucks supplied by the Government to the states at an almost negligible cost much material may be hauled in these trucks for long distances. The ton-mile cost of hauling in trucks which cost the states practically nothing is greatly reduced if the factor of original cost of the trucks does not have to appear in the figuring.

State Ownership

Some of the states have adopted the practice of furnishing the materials of construction, or most of them, to the contractors. The writer does not know of any state which has gone so far as to own cement plants and rock quarries and to operate them but that such a policy may have to be adopted by some states is by no means unthinkable. Indeed, the statutes of some states provide for such a contingency. For such states as have become accustomed to supplying the contractors with construction materials it would be a simple extension of their operations.

There is little doubt that the heavy road building program will be in fashion for a long time to come so that the plant construction cost may be distributed over a huge quantity of the product. If the cement companies are unreasonable in their prices, for instance, a means for curbing them is available.

However, the money involved in such undertakings would be in large figures and could be allotted only with difficulty in some cases. "We want the money spent on the roads" is still the slogan of many of the thoughtless voters of state highway bonds.

It must be confessed, too, that under normal conditions no state operated cement plant can hope to compete with a privately operated plant on the cost basis.

Furnishing Materials to the Contractor

There are many advantages and few objections to the state highway department furnishing materials to the contractor. A contractor with little capital is enabled to bid on work since he has little to finance outside of the labor and equipment items.

The contractor has no incentive to scamp on quantity or quality of the materials. Indeed, he must be watched to prevent his wasting them.

All disputes with the contractor as to the quality of the materials are eliminated.

Because of the larger volume of materials in which it deals, the state can usually secure lower prices per unit than can the individual contractor.

The contractor will insist, of course, on prompt deliveries. He will be much more critical in this respect than if he were doing the purchasing himself and he may make claims for damages due to faulty deliveries but the state should and can operate better than the contractor in this respect.

It costs something to handle the business end, of course, for purchasing agents and clerical people to buy and route the materials, and for this service the contractor, when he furnishes his own materials, charges from 5 to 10 per cent. of the value of the materials. This cost is reflected, necessarily, in the administrative costs of the state highway department and there is much bother connected with the supply of materials to the contractor. The advantages, however, seem to outweigh the disadvantages.

Testing of Materials

So much costly paving is involved in modern state highway construction that the testing of the materials used becomes an important division of the work.

The geological work and the testing may be combined in one department without difficulty and a highly trained geologist may be placed in charge of both branches of the work.

It is hardly possible to make up cost estimates until the sources of supply of the materials are known and the geologist and the testing engineer often settle the matter for the engineer.

After construction work begins it is necessary to know how the concrete mixtures, asphaltic and Portland cement, are working in order to get the best results, since, although the ingredients have all passed the specifications satisfactorily, the limitations of the specifications for the combinations nearly always permit some latitude.

Also, it is interesting to know, for instance, the compressive strength of the concrete in the pavement slab after the road is completed.

A testing laboratory can be set up at no great cost, probably in no case exceeding $10,000, which will do all the testing required in the general line of work.

The United States Bureau of Public Roads requires the tests to be made and it seems to be advantageous to have the work done as a state highway department matter rather than to rely on private firms of testing engineers.

LOT AND BLOCK PLANNING IN RESIDENTIAL DISTRICTS

By Arthur C. Comey, City Planner, Cambridge, Mass.

It is to be assumed that in the normal case a proper layout of main streets and disposition of public grounds will permit the minor streets to be so arranged as to produce the optimum in block lengths and widths, the latter closely affecting lot depths. Lot widths, on the other hand, are not controlled to any large degree by other elements in the plan and may, of course, readily be changed at any subsequent time prior to development or actual sales without materially modifying its general relations, said Mr. Comey in his recent address at Ottawa, Ontario, at the joint meeting of the Town Planning Institute of Canada and the American City Planning Institute.

Factors Controlling Width

The factors controlling the width of interior lots are, on the one had, adequate width for the dwelling itself, light and air in its yards and (to a less degree) passage for automobiles; on the other, the cost of utilities in the street, which rise rapidly as lot widths are increased and practically require the minimum adequate width to be the standard, if not the maximum as well, except as topography and other elements in the plan fix certain points and permit somewhat larger lots without increased expense. A house nearly square is the most economical, so that, except where under the spur of high land values lots have been plotted too narrow, the two-room-deep house is the usual type.

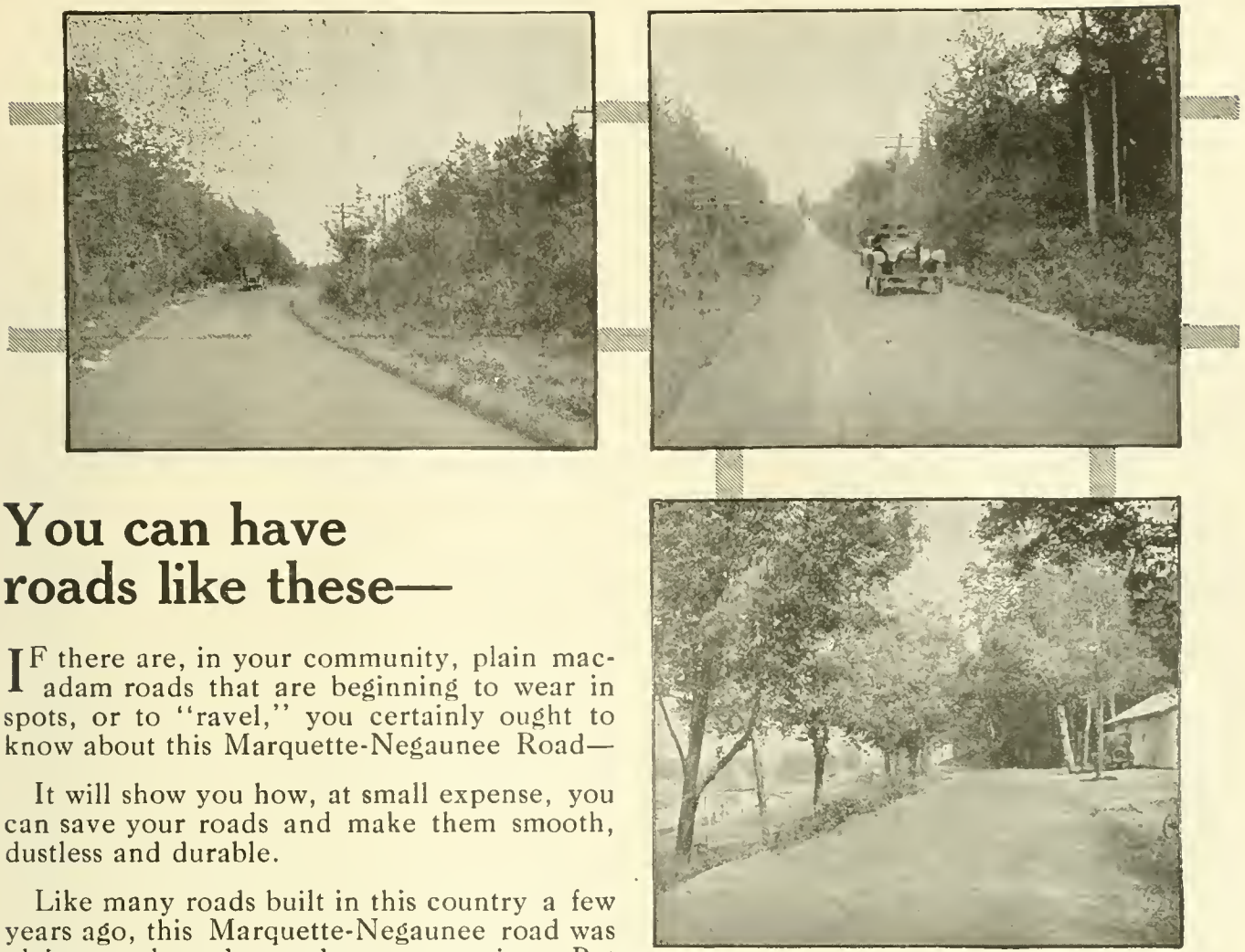
For detached houses, 7 or 8 ft. is the minimum side yard width to assure sufficient light and air at the first story, as well as safety from fire. One side yard should be at least 10 ft. wide to provide space to drive an automobile. The square house is probably the widest that should normally be provided for. The 6-room house may be as small as 22 ft. square, the 7 and 8-room types running up to 26 or 27 ft. The proper standard minimum lot width for detached houses is 40 to 44 ft. Unless 40 ft. can be obtained, semi-detached or row houses should be planned.

For semi-detached houses, 10 ft. is none too wide a side yard for light and air as well as for the passage of automobiles. Such houses need not be over 23 ft. wide and are frequently not over 20 ft. The proper standard minimum lot width for semi-detached houses is 30 to 33 ft. In sections with moderate rentals it is proper to mix detached and semi-detached houses according to any scheme of grouping the city planner and architect may work out. Each pair of semi-detached houses requires 1½ lots of a size suitable for detached houses. In cases, therefore, where it is desirable to plat lots in advance of building, the 40-ft. width, or better, 44 ft. may be used as a standard minimum.

Mingling of Types Undesirable

Three reasons prevent the advantageous mingling of row houses with the other two types: An alley is usually required behind the row house, a considerable expense, which constitutes an unnecessary burden if incurred behind houses with side yards and therefore not dependent on alleys; the larger building units are apt to be out of scale with the other types; and in most cases the type of occupancy is different. The row of three houses placed at intersecting streets may be used with semi-detached and detached houses by adding to the rear yard of the middle house an extension 10 to 20 ft. wide, reaching the side street across the rear of the corner lot. The unit of three will require about two lots of the size for detached houses, and therefore fits into a scheme of 40 to 44-ft. lots.

The row house attains practically its full economy with 5, 6 or 7 in a group. Above 9 the inordinate length of the row becomes unpleasant architecturally, and at the same time increases fire risk and steadily decreases venti-



You can have roads like these—

IF there are, in your community, plain macadam roads that are beginning to wear in spots, or to "ravel," you certainly ought to know about this Marquette-Negaunee Road—

It will show you how, at small expense, you can save your roads and make them smooth, dustless and durable.

Like many roads built in this country a few years ago, this Marquette-Negaunee road was plain waterbound macadam construction. But after it had been in use for a while the road authorities of Marquette County discovered that plain macadam would not stand up under the torture of modern traffic.

The road authorities had to find some way to save their road, which is an important main highway carrying heavy traffic. They turned to Tarvia as the surest and most economical solution of the problem.

They treated the road surface with "Tarvia-B" in 1917. In some places where the wear had been particularly severe a second treatment was applied in the summer of 1918.

Three different sections of Marquette-Negaunee Road, Marquette County, Mich. These roads were waterbound macadam treated with "Tarvia-B" in 1917 and 1918. This is the main line of travel between the busy mining cities of Ishpeming and Negaunee, Mich. A traffic census revealed the passage over this road of 1980 vehicles per hour, the majority of which were automobiles.

Today, instead of a ruined macadam road which would soon have to be rebuilt at great expense, Marquette County has one of the finest stretches of road in all Michigan, as the photographs show.

And the road can be *kept* in the same wonderful condition at small expense by occasional Tarvia treatments.

Advice on your own road problem can be had from the nearest Barrett office.

Tarvia

Preserves Roads—Prevents Dust

Special Service Department

This company has a corps of trained engineers and chemists who have given years of study to modern road problems. The advice of these men may be had for the asking by any one interested. If you will write to the nearest office regarding road problems and conditions in your vicinity, the matter will have prompt attention.

The Barrett Company

New York, Cleveland, Birmingham, Seattle, Youngstown, Chicago, Cincinnati, Kansas City, Peoria, Toledo, Philadelphia, Pittsburgh, Minneapolis, Atlanta, Columbus, Duluth, Richmond, Milwaukee, Latrobe, Dallas, Bangor, Bethlehem, Boston, Detroit, Nashville, Washington, Elizabeth, St. Louis, New Orleans, Salt Lake City, Johnstown, Buffalo, Baltimore, Lebanon

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lation in the block. Such relatively short groups obviously require special lotting. The lot widths for interior houses are controlled absolutely by the design of the house. To secure adequate light and air, row houses should not be more than two rooms deep. The usual plan is one large room across the front and one or two smaller rooms at the back. The proper width for such a house is 18 or 20 ft. The end houses of rows may be put on lots 27 to 30 ft. wide, so that two such end houses of adjacent groups require three of the lots designed for interior houses.

It is difficult to make a lotting scheme which will serve for both row houses and for semi-detached and detached houses. In cases where row houses are anticipated, lotting should accompany the plan for grouping the dwellings instead of preceeding it.

Expense is in Frontage

While it is generally recognized that 50 ft. is sufficient distance for light and air between the fronts of small houses, and while this same distance is also a sufficient minimum between backs, in practice such shallow lots as these dimensions produce are seldom found necessary owing to the fact that added lot depth does not correspondingly increase the cost of most utilities. It is frontage that is expensive, and rear land must be considered to remain close to the acreage cost of raw land. This is a particularly important factor where topographical conditions or irregular boundaries would involve considerable extra length of streets to produce but few more lots of standard depth, the alternative of fewer and deeper lots with much less street construction being much cheaper and involving only a slight loss in gross selling value.

On all except the main thoroughfares, the needs of traffic are not sufficient to affect the distance between the fronts of houses. In detached house neighborhoods, experience indicates that 20-ft. front yards are not excessive. For semi-detached houses, 15 ft. is found suitable. For row houses, 10 to 15 ft. may usually be provided. A variation in set back not exceeding 5 ft. usually adds to the attractiveness of the street. Unnecessary depth runs up the cost of service lines from the utilities that are placed in the street. If the street lines were placed at the building line, as in Washington, D. C., the utility lines might be run close to the houses, thereby saving considerable expenditure necessary under any of the present methods.

Houses of moderate price normally range from 18 to 32 ft. in depth, the vast majority being from 20 to 30 ft. deep, though certain designs for narrow semi-detached houses may require 34 to 35 ft. In the depth of rear yards even more variation occurs, both because their use varies and because it frequently proves to add so little to the cost to make them ample. For detached houses, an ample garden space for a person working elsewhere during the day is 40 by 50 ft. If not so used, this is still not too large for children's play.

On streets of ordinary width, lots for detached houses should normally be planned 90 to 110 ft. deep; for semi-detached houses, 80 to 100 ft.; and for row houses, 70 to 90 ft., including to the center of alleys where introduced.

Where extreme land values do not preclude, a scheme of lots based on a standard minimum of 40 to 44 ft. by 90 to 100 ft. is proper. In extreme cases, where row houses are certain to come, lots as small as 16 to 18 ft. by 70 ft. may be necessary, but intermediate widths so common in most of our cities are not easily adapted to modern housing standards.

Corners are Special Problems

The best size for corner lots in cases where practically all the houses are to face one set of roughly parallel streets may be fixed as ranging from the same width to 5 ft. wider than corresponding interior lots, and approximately the same depth.

With houses fronting on all streets, to secure the maximum salable frontage and the least interruption to the architectural motive along each street and around the corner, the corner lot is best made approximately square. It should be equal in area to the corresponding interior lots. A somewhat large square corner lot may be cut diagonally in two, and a pair of semi-detached houses set across it, though this expedient is not always pleasant. It is not apt to be a good plan to attempt to crowd houses at a street intersection and still give sufficient square feet of rear yard space by violent skewing or irregularity in lot boundaries. Acute interior lot corners should be particularly avoided. Lot lines should usually be run back at least 40 ft. to a point not less than 5 ft. behind the house, approximately at right angles to the street.

Block widths are normally twice lot depths, though many irregular blocks are bound to be platted, especially in layouts on rough or peculiarly shaped land, to economize in construction cost and in land used for streets.

Block lengths are controlled by the needs of traffic, both vehicular and pedestrian, and by factors of safety. Experience shows that in residential areas, blocks 600 to 700 ft. long cause little dissatisfaction. Shorter blocks are wasteful of land in cross streets. Blocks longer than 800 ft. are found to cause undue detours in going from one side to the other. This is more noticeable in the case of foot traffic than the modern automobile. Inasmuch as adequate footways require but one-sixth the space of cross streets, and even less proportionate construction cost, their use midway across blocks of lengths up to 1,200 ft. is permissible, particularly in districts with steep slopes, making connecting streets expensive. In areas designed with deep courts and blind streets only partially cutting up the blocks, if each such court and street has a path leading from it across the block, most of its disadvantages will disappear, though it will still be less easily policed or protected in case of fire than regular blocks.

While variations to the ordinary block and lot system which do not easily conform to rule have hitherto seldom been laid out, the increased attractiveness attending their use in a reasonable number of instances demands that the opportunity be not closed by rigid standards. As they are apt to be integral parts of the group designs for the actual houses, their layout cannot be determined until the building program is adopted. Where interesting variations are not anticipated, the minimum standard of blocks, 180 to 200 ft. by 600 to 800 ft., with lots 40 to 44 ft. wide, is more apt than any other to be adapted to the future needs of a neighborhood.

WATER WORKS SECTION

WATER WORKS IN 1865 AND IN 1920

By John W. Hill, Consulting Engineer, First National Bank Bldg., Cincinnati, Ohio

Water Works in 1865

When the Civil War closed (1865) there were in the United States about 150 cities and villages having works for public water supply, and many of these furnished water under very low pressure. At that time there were no public water works in the states of Maine, North and South Carolina, Florida, Mississippi, Texas, Arkansas, Iowa, Wisconsin, Nebraska, Minnesota and Nevada; twelve states in 1865 without a single public water works.

Pumping works were confined mostly to the large cities while many of the smaller cities and villages developed nearby gravity sources. The cities of Columbus, Dayton and Toledo in Ohio; Indianapolis, Terre Haute and Evansville in Indiana; Covington, Newport and Lexington in Kentucky; Knoxville, Nashville and Memphis in Tennessee, and Peoria, Springfield and Bloomington in Illinois, had no public water works at all. This also was true of other cities not mentioned. A public water supply was a luxury not thought of by many populous cities in 1865, and no one at that time was specializing in water works machinery and equipment. Stop valves and fire hydrants were usually made by the city using them and large pumping engines were of special design and seldom duplicated.

One gravity works in an eastern state made no direct charge for water to its 40 consumers, assessing the small cost of maintenance each year upon all the takers instead.

Following the Civil War with its previously unheard of profits to merchants and manufacturers, huge fortunes made from army contracts and flotation of government bonds, extraordinary expansion of the currency, and other financial conditions, which we are again experiencing after a lapse of 55 years, came an era of municipal improvements including water works, gas works, street cars, pavements, handsome and commodious public buildings, street lighting and other things which then were luxuries and now are necessities according to our mode of living. Previous to that date (excepting the city of Cincinnati) fire protection was mainly obtained by buckets and hand fire pumping engines taking water from large cisterns constructed in the streets or from fire hydrants furnishing water at low pressure. Prior to the Civil War a few cities other than Cincinnati had steam fire engines of Cincinnati manufacture.

The Holly System

The cost of pumping water works with specially designed machinery was prohibitive in all but the larger cities, and not until Birdsall Holly of Lockport, N. Y., offered his rotary pump for fire service and quadruplex piston pumping engine for domestic service, was there anything in the market especially adapted to water works for the smaller cities.

The Holly system, as all know, consisted of pumping directly into the mains without the intervention of standpipes or reservoirs, the pumps running at a widely varying speed according to consumption. The Holly system gave the initial impetus to water works construction in the early years following the Civil War, and soon had many imitators. The essence of the system was an automatic pump regulator actuated by the pressure in the discharge main.

The same thing that happened in water works development and expansion after the Civil War, will happen again, within a few years, when municipal finances again are normal and funds are available for the many improvements and extensions now needed. Few cities are now fully abreast of their water works requirements, the great majority are behind in all respects, and few improvements are now being made excepting where funds were provided before our entrance into the World War. Some work is progressing in those cities in which improvements depend upon the surplus from water rent, but in all instances where funds are to be provided from municipal bond issues, there has been a marked halt during the past three years. In the words of Dr. Munyon "there is hope" for city water works improvements in the near future.

To those who are alarmed at the present high prices of water works materials, it is well to remark that in 1869-70 cast iron water pipe sold in the Western market (bounded by the Mississippi river) at $100 per short ton, fire hydrants at $100 each, stop valves in proportion, and pumping engines of special design cost as high as $15,000 to $20,000 per million gallons daily capacity.

Delayed Improvements

During the past two or three years many water works have stood still in the matter of improvements and extensions, for lack of money to carry out the projects necessary to keep the works abreast or in advance of real requirements. New or additional pumping engines, boilers, stokers, heaters, feed pumps, extension of distribution mains, increased capacity of supply mains, additional storage, modern and adequate systems of water purification, and other details, are among the things that water works managers and cities need to bring their works up-to-date.

During the past two summers, some cities have been threatened with, or actually had water famines, from inadequate or run down pumping equipment, or for lack of proper mains to supply and distribute the water. Some although provided with filtration and chlorination works have been required to warn consumers to boil the water to avoid typhoid fever.

The splendid results obtained during the last 20 years in the reduced typhoid fever rates by filtration of polluted

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water supplies, is an argument which no city or water company can resist, and the only cause of delay in the universal adoption of the most efficient methods of water purification, and the complete elimination of typhoid fever so far as a polluted water is the carrier of the germ, is the lack of money. Every works must supply some kind of water for manufacturing, commercial and sanitary purposes, and for fire protection, even though it may not be fit to drink, and water purification, therefore, under present practice becomes the last step. It should not be so, for life and health are the most important things to conserve in a public water supply.

Many writers have proven from official statistics, the money value to a person and the community at large, of a public water supply free at all times from typhoid taint, and this has been done to show the public and those responsible for a public water supply, that even considering human beings as a collection of animals, or to put it more plainly, as a bunch of horses, cattle, and hogs, it will pay to furnish them with a drinking water that cannot possibly lay the foundation for typhoid fever.

This argument appeals only to the sordid side of life; but surely there is something higher and nobler in preserving a human being from disease and death, than the money value he may be to his family, and the community of which he is a member. It should not be necessary to put the humanitarian value of a pure water supply into dollars and cents to convince the city or water company that a drinking water should be always wholesome as a matter of simple justice to its users.

The advance in the refinements of water purification by the use of bleaching powder, (hypo-chlorite of lime), liquid or gaseous chlorine, direct oxidation of organic matter by electro-chemical process, and the ultra-violet rays, are of recent birth in their practical application, and time will be required to determine the best method of treatment after filtration, if the water is of surface origin.

Ground waters though otherwise satisfactory, will sometimes require treatment to render them safe for drinking purposes and the advanced methods of water treatment will here apply. Where ground water is the only available source of public supply and this (as usual) contains high parts of lime and magnesia, water softening apparatus is sometimes used to "break" the water and make it more acceptable for laundry and bath purposes. The softening process is also a purifier of bacteria, but even with a naturally pure hard water it is desirable to render the water soft for domestic and many commercial purposes.

Some water works have filtration systems too antiquated for present use, or of insufficient capacity, and these will require modern methods of filtration or enlargement of the works to provide a safe and ample capacity for the present and future.

Water Rates

Public Utility Rates cannot be kept down when the cost of all labor and materials entering into the maintenance and operation of the utility are steadily rising. A water rate established by ordinance 20 or 30 years ago, or even 10 years ago, when cast iron pipe could be bought at $25 to $30 per ton, lead at 4 cts. per pound, common labor be had at $1.50 per day, and other things in proportion, whether the service be furnished by a municipal or a private corporation, cannot fit the prevailing costs of all labor and materials. A municipal corporation may be able for a time to maintain the ordinance rates by carrying a floating debt, and issuing short time notes, but some day the obligations must be liquidated from earnings, and excepting there be a sharp reaction in the costs of labor and materials, the rates must be increased in order to meet the current expenses, and interest and sinking fund charges on bonded indebtedness. The latter was established years ago when bonds were issued, and before the era of high cost created by the World War, and is not affected by the conditions complained of, and it may be said the property value is no more than the capital actually and honestly invested in the works, although as shown by the recent railway investigation at Washington the reproduction cost today may be 50 per cent. more than real cost as represented by bonds and investment from earnings of a municipal works, or by stock and bonds of a company works. Of course, interest and redemption charges are not being paid to holders of securities on the inflated or speculative values of the properties as of today but on the values as represented by obligations issued, generally years ago, and before the rapid rise in cost of labor and materials.

Labor and materials, however, required for maintenance and operation are now higher than they have been for over 30 years, and the increased cost must be met from income from service to the public. This is true of all public utilities, and many increases have been allowed and sanctioned by State Railroad and Public Utility Commissions, in order that the Public Utilities operated under franchises may not be forced into bankruptcy or receiverships. Federal receiverships will provide rates sufficient to pay all operating charges including absolutely necessary extensions and improvements, interest on bonded indebtedness and create a reasonable depreciation fund.

A municipal corporation can raise the water rates at any time by ordinance of council or the city commission, and while the consumers can, and always do, complain at higher rates for water, gas, electric current, and trolley fares, in the language of the Arabian Nights "there is no help for it" excepting a return to the good old conditions of public utilities prior to the World War.

Water Meters

Water meters were scarcely known in 1865. Before that date the existing water works supplied the consumers under what we know as flat rates, and one works at least in an Eastern State made no charge whatever, to its consumers, the small expense of maintaining the service was assessed per annum, pro rata on the 40 water takers. This was a gravity works, and the annual cost of maintenance was small.

The modern water meter has had a large influence on the cost of operation, perhaps quite as much as the high duty pumping engine, and the two have been the factors in reducing the cost of pumping, and in affording protection against waste of water. Invention and improvement in this case have kept pace with necessity, and the low per capita cost of public water supply in most instances is in large measure due to the liberal use of water meters.

The early water meters were heavy and cumbersome and some of them of no utility whatever. It has been stated that during the reign of the "Tweed ring" in New York about 50 years ago, the purchase of thousands of

useless water meters was one of the prolific sources of graft. Thousands of meters bought by the "ring" during its days of power, were afterwards found stacked in the basement of the City Hall, not one of which, it is said, was ever set or used.

These meters were bought at prices several times their real value, had they been useful, and their purchase was not intended to prevent waste of water but to facilitate the flow of money from the City Treasury into the pockets of the "gang" of which Wm. N. Tweed was the chief Sachem and beneficiary. The plunder of the "Ring" was enormous but in proportion a mere bagatelle to the waste and graft of the late Army contractors and their satellites, or of the unholy gains of the modern profiteers. If Mr. Tweed, Mr. Connolly, Mr. Hall and many others who shared in the New York "steal" were alive today and reading the revelations which investigating committees of Congress are making of the unnecessary and wasteful expenditures for cantonments and other war institutions, and the enormous profits of the people who are trafficking in the necessities of life, they would blush for shame and wonder why such a hullabaloo was raised about their paltry graft of a few millions, less than two generations ago. Tweed was properly punished for his shortcomings, and perhaps our dishonest War Contractors and "profiteers" will also be made to answer for their crimes in due time.

The water meter favored by Mr. Tweed was intended for a "steal" while the modern machine is intended to promote "honesty" in the accounting for water drawn from the public mains.

Private water companies have from the beginning, regarded water meters as an essential of their equipment, and it is only the municipally managed works that has ever looked with disfavor on them.

Future development will largely increase the use of water meters, until generally water will be furnished and charged only by reasonably exact measure, for the meter is not a "balance" or instrument of precision, and with constant use, and sometimes with no use at all, when connected in a line of service pipe, the original so-called accuracy of the meter will change, always however, in favor of the consumer. The wear and increasing "slip" of the meter will represent a larger volume of water passed than that indicated by the register, and the instances are not few where a water meter has altogether ceased to register the flow while the normal amount of water was going through it, the consumer having no knowledge of trouble in the meter.

Ownership of Water Works

Since the advent of the world war, there have been few or no appraisals of public utilities for purpose of sale to municipalities, but many for rate adjustment, made necessary by the increased cost of labor and materials due to war conditions. It is not probable that there will be many sales of water works to municipal corporations for some time to come. The unfortunate financial experience of the federal government in the operation of the railroads has put a crimp in the mania for municipal ownership and operation of public utilities, and it will require a few years, at least, to convince an intelligent and thinking public that water works, gas works, electric lighting works and trolley lines can be better administered by

24-inch line looking south from Dam, through Medicine Canyon.

30,000 Feet of 24-inch

"U. S." Bell and Spigot pipe laid through the roughest kind of country; huge boulders, dips from 12 to 20 feet, and ALL WITHOUT A SPECIAL CASTING OF ANY KIND. The line has given excellent service, testifying the economy and advantage of the Bell and Spigot joint.

Cast Iron Pipe holds many service records in this country—112 years in Baltimore, 100 years in Philadelphia, 80 years in New York, etc.

Write for further details.

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professional politicians, than by trained business and technical men who have devoted their active lives to the study of, and experience with, problems entering into the construction and operation of public utilities.

The construction and maintenance of streets, roads and bridges, of sewers and sewage disposal works, the exercise of police powers and fire protection, are properly public functions because none of these things can be properly bartered to a private corporation under a municipal franchise. There are a very few instances where cities have granted franchises for the construction and operation of sewers, but none that have worked successfully, even though connection with and use of the sewers was compulsory. Sewers, and street lighting (which is part of our police regulations), can best be managed by the municipal corporation in the interest of the people as a whole, but the electric current or gas for street lighting, should be purchased under contract from some one who is concerned in making the commodity for general use, as a rule only a small part of which is taken for strictly public purposes.

Bridges in some instances in the distant past, have been constructed and are now maintained and operated under public franchises, but generally speaking, a bridge is a part of a highway and highways are properly part of the municipal or county *ensemble*.

It would be difficult, excepting by taxation, to fix the price each property owner or citizen should pay for such construction and maintenance of highways, bridges, sewers, street lighting, and police and fire protection, because all these are not susceptible of measure to the individual like water, gas, electric current and rides on the street cars; they confer general benefits, the cost and use of which should be shared by all.

This, however, is not the case with respect to water, gas, electric current and trolley rides, which the individual can use according to desire or necessity and pay for by measure.

Assuming that the rage for municipal ownership of public water works is not now rampant the appraisals in the near future will be for "rate making" and the rules generally laid down by the State Public Utilities Commissions and by the courts, will have weight in forming a correct judgment upon the value of these properties. In making the inventory of tangible property many articles will always be found which have been set aside temporarily and which would have no value in the opinion of a buyer, and yet in the mind of an owner would have a possible value, such as pumps, boilers, gas exhausters, air compressors and other details which at the time of appraisal are in the discard, although such details are often overhauled and restored to useful service. If, however, such articles are worn out and no longer "used" or "useful" in the works of which at one time they formed a part, it is fair to assume they have been "amortized" in the depreciation fund, and if this has not been done by the owner, the U. S. Supreme Court in the Knoxville Water Co. case has stated the "fault is its (his) own." In any event if the thing is not now "useful" it should be excluded from the inventory.

HOW TO CONDUCT BOND CAMPAIGNS FOR MUNICIPAL IMPROVEMENTS

By Robert E. McDonnell, of Burns & McDonnell, Consulting Engineers, Interstate Bldg., Kansas City, Mo.

Many engineers of experience and ability prepare and present plans and lengthy reports covering needed municipal improvements. These reports are often marvels from an engineering standpoint and represent months of study and investigation of every phase of the question.

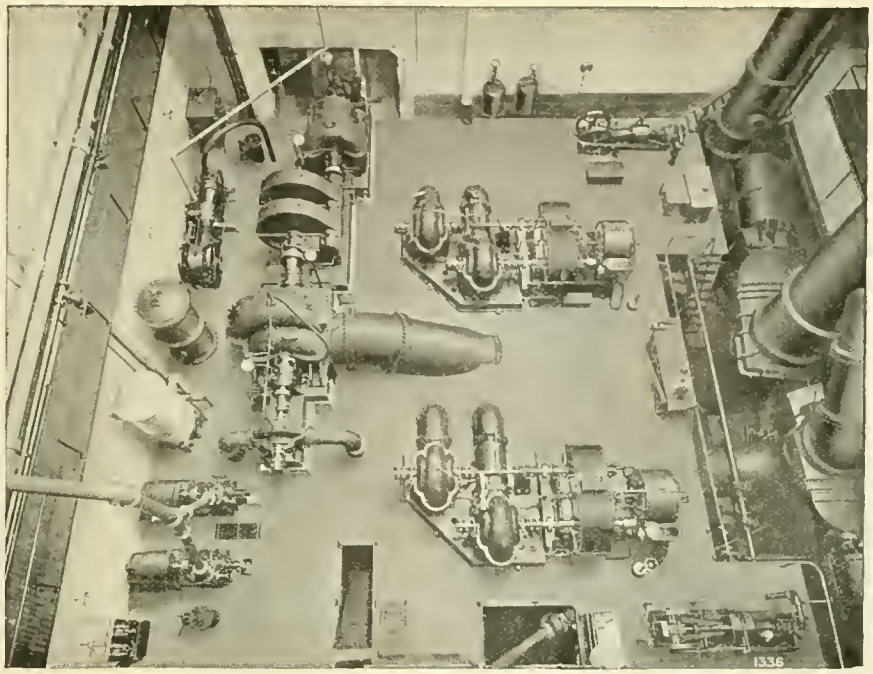
One report recently was brought to the attention of the writer covering a six months' investigation of the available water supplies of a Western city. The report was a voluminous document of over 600 pages with 33 pages covering table of contents and 15 pages devoted to a list of references. The climax, summary and recommendations on the last page occupied less than twenty lines and was the only part of the document that interested 99.99 per cent. of the voters, who paid for the report. This percentage is arrived at by assuming there is one engineer to every 10,000 people in a community, and it is absolutely safe to assume that the engineer is the only person in the 10,000 who will read the report, and he who does read the report, shows by doing so that he belongs to the class of either out of a job or a paid reviewer.

Reports Too Technical

Most engineers' reports like this one are really prepared with the ultimate object in view of a bond issue for the improvements, yet to read one through, which is never done, one would think they were written to impress the laymen with the technical training of the author. In this same Western city a heated controversy is now raging as to what should be done about the future water supply. The report tells what should be done, but not in a way that is readily grasped and understood by the 99.99 per cent. of the people. The engineers who prepare fine, readable reports are only doing a small part of their work, the real value of an engineer's service to the public comes in presenting his subject so clearly to the voters that everyone will see it, understand it, talk it and VOTE for it.

The Illustrated Bond Campaign

Many worthy projects are never brought to a vote and many equally worthy ones are voted down merely because the engineer failed to properly illustrate the various features. In your own experience, how many times have you, as an official, known to your own satisfaction the need of a bond issue for water, light or sewer improvements, yet you hesitate merely because the public does not possess the same knowledge as you possess regarding the improvement? You cannot go out and individually talk and convince every one of your friends of the need of the improvement, but the illustrated bond campaign does this for you. Only recently a conference with some Iowa city officials disclosed a polluted water supply and an inefficient lighting plant. The Mayor remarked: "We know the needs of the plants and have voted AT it, but met defeat three times." The defeat of worthy projects is invariably due to two causes—poorly presented and not understood or lack of confidence in the administration. In the Iowa case it was poorly presented but, following a three weeks' campaign, wherein every phase of the project



Filtration Pumping Station, City of St. Louis, showing two class "A" units, 40 million gallon capacity, and the new unit of 100 million gallon pump, all pumping against 60 ft. head.

Repeat Orders for De Laval Pumps

One De Laval pumping unit in a plant is usually followed by others.

This has happened at Cleveland. Toronto, Philadelphia, Indianapolis, etc.

Some years ago the City of St. Louis bought two De Laval pumps of a combined capacity of 30,000,000 gallons, driven by single-stage geared turbines, as shown in the above photograph. Recently greater capacity was required, and the De Laval 100,000,000 gallons per day geared steam-turbine-driven centrifugal pumping unit, shown at the left side of the picture, was purchased. The circulating pump for this unit is coupled directly to the main pump shaft.

All of these pumps discharge against 60 ft. head.

The tremendous saving in cost of buildings and foundations resulting from the use of centrifugal pumping machinery in this plant is apparent. The super-structure need not be high nor heavy, as only comparatively light parts have to be lifted by cranes.

The steam economy of De Laval turbine-driven centrifugal pumps is equally as remarkable as the saving in first cost. State your conditions fully, and estimates upon which we are prepared to base guarantees will be given.

DE LAVAL STEAM TURBINE CO.

515 Johnson Avenue **TRENTON, N. J.**

92

was illustrated, the improvements were almost unanimously authorized.

Pictures

Pictures are plainer than print—they present pertinent points only. They are in the language the people know and understand. Photographs of inefficient machinery and its cost of operation are shown by stereopticon slides, followed by one showing EFFICIENT equipment and the saving in operation costs. Alleys showing outhouses, garbage piles, ash heaps, etc., make good illustrations of the lack of sewers and sanitation and contrast this with stereopticon slides showing abandonment of alleys with the installation of sewers, with its beautiful back-yard flower beds and creek banks beautified.

Use of Vital Statistics

Health statistics graphically shown on a slide of your own city, even showing poor results and you are ashamed of them, serve to stimulate an interest in bettering the conditions. Slides showing the typhoid rates of other cities with pure water supplies emphasize the need of action in your own city. Typhoid and many other water-borne diseases are preventable diseases, preventable by proper precaution in water supply, food and sanitation.

The time is fast coming when the sheriff and police officers will investigate and fix the responsibility for every case of preventable disease. Doctor Hazen, an authority, says for every case of typhoid someone ought to be hanged. The real town booster gains nothing by covering up and minimizing the town's sore, festering and ugly spots, but let them be known and the town will soon have none of these to apologize for.

Slides and Moving Pictures

Proper publicity and presenting of engineering reports needs no exaggeration to make the argument effective, but a real portrayal of plain facts by slides and moving pictures merely brings to the attention the need of improvements, and where the necessity is shown, the cash is always forthcoming.

During a campaign for sewers and a modern sewage disposal plant, recently, the writer found the moving picture shows all anxious and willing to show such films as "The Daily Life of a Fly;" also, the public meetings were packed to see the plans and estimates shown on the screen, illustrating the proposed improvements, together with pictures showing the best examples of similar improvements in other cities.

There is no municipal improvement that cannot be graphically illustrated by pictures and diagrams and they are plainer than printing or typewriting. Maps showing water or sewer lines, with their sizes and locations, can be shown by slide. White-way or ornamental lighting can be well illustrated. The writer has conducted successful campaigns for bonds by this method, covering such a variety of subjects as the following: Campaigns for municipal ownership of water works and lighting, for sewers and sewage disposal plants—new water supplies, filtration systems, water power, park and street improvements.

Fear of the People

It is an unfortunate fact that many a needed public improvement is delayed to the point of criminal negligence on the part of those in authority, solely on account of their fear that public sentiment may be against the improvement.

The superintendent of the city water works may know that the water supply is inadequate or that the pumping machinery is insufficient to give fire protection, and he may confide this alarming situation to the other city officials, only to be told to keep the matter hushed up, as they do not dare ask the people to vote bonds until after the spring election, and they will try to pinch along another season on their present equipment. They are willing to gamble against Fate. They take a chance, and sometimes they lose, or, rather the public loses property worth many times what the water works improvements would have cost; and that is not all—the public then awakens to the necessity and rebuilds its water plant—and if justice falls where due, the public also selects new city officials. But this illustration pertains only to property loss—material things. I have in mind a far worse negligence—criminal, without a doubt, but wholly due to the fear of taking the public into the confidence of those responsible for public property. This is a case where a city is supplied with pure water, but the plant facilities are not adequate to meet the requirements of the dry season, and as a consequence of this condition of affairs it becomes necessary to introduce polluted water into the city mains at times during the hot summer season. The superintendent of this water works system told me he was simply "up against it" and he did not dare mention the true situation publicly for fear of the storm of indignation that would fall upon him. And yet this city failed to vote bonds for an increased pure water supply when the question was submitted to a vote. The reason it failed was plainly due to the fact that the city officials did not have any definite plan prepared to show how they proposed to use the money, nor did they make any organized campaign to educate the public to the necessity of the improvement.

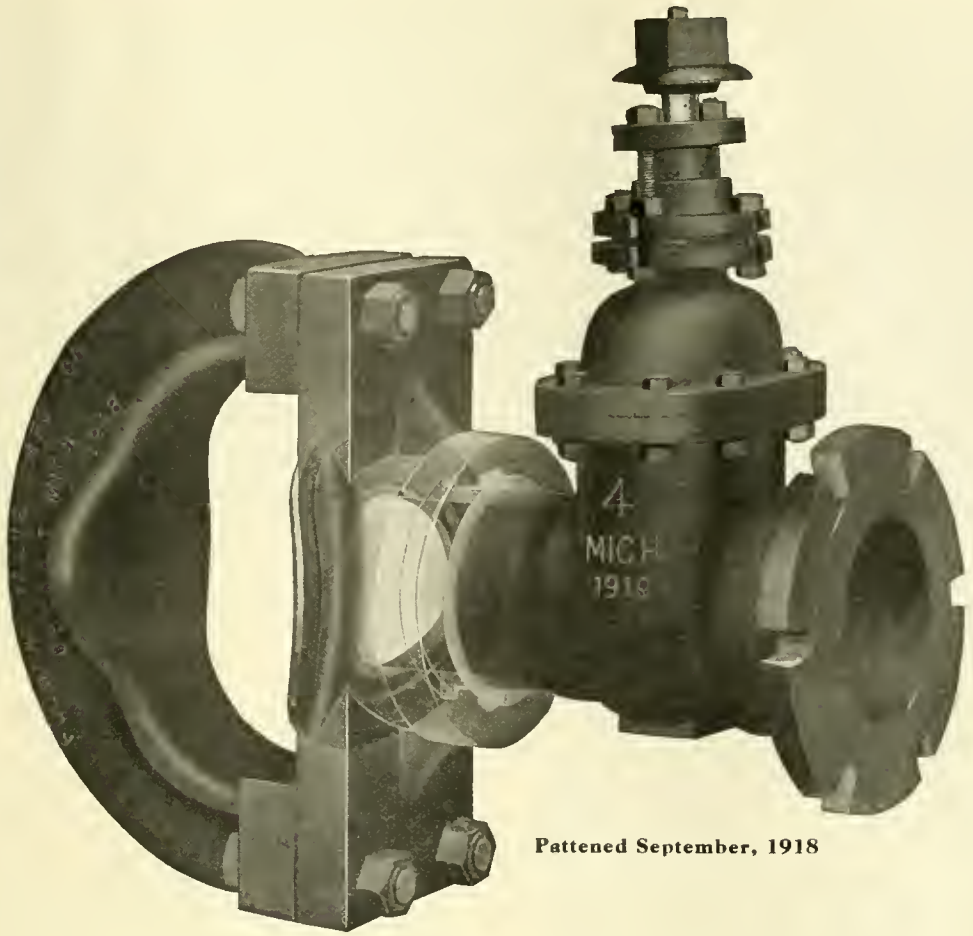
The average engineer's report on improvements is too long, dry and technical and frequently leaves the officials in the air as to what to do next. The real job of raising the funds is as much the engineer's obligation as showing how much is needed.

Call an Engineer Early

Many municipalities make the mistake of proceeding with a bond issue without first having an experienced engineer's report covering cost, comparison of various features and recommendation about the project, with the result that when voters are asked for bonds, the questions the voters ask about the project cannot be intelligently answered and the officials are put in a defensive position and the voters are groping in the dark as to some phases of the question. Then again, the cost, or amount of bonds, will be questioned unless it is based on a very carefully made plan and estimate.

A wrong impression or conception of a project often defeats it. The voters have a right to know and should know every detail of the project before voting.

The correct cost and proper explanation of the project, or the first impression of it, is the lasting one, and this should be given at the outset and not after there are hundreds of half-baked opinions spread broadcast regarding the projects. An engineer's greatest value to the community comes in by properly conceiving the character and extent of the work before a bond election and, like the skilled diagnostician in studying the symptoms, the causes, etc., he can prescribe correct treatment before mistakes are made. Cities often fail to realize that it costs no more



Pattened September, 1918

Get the Facts on this Sleeve

The new Flower sleeve has saved time, money and labor in making taps the country over. Engineers everywhere have quickly recognized its value.

If you haven't had details of this improved sleeve with the "built-in" lead, send for it at once. We want to have a copy of the sleeve data sheet in every engineer's files.

Flower Valve Manufacturing Co.

117 Parkinson Street Detroit, Michigan

(24)

for an engineer's services right at the outset than it does to call him in after funds are provided.

An improvement that may apparently seem dry and uninteresting can in this way be made such a live, interesting subject that civic organizations, women's clubs, labor unions, etc., are seeking an illustrated talk before their organizations, which not only instructs, but entertains. How many people nowadays would go to hear a paper read or a lecture, even if ably presented? The public likes to see as well as hear, and to see by slides what their neighboring cities are doing helps to do better our own problems.

Graphic Presentation

This method, of course, involves much added work for the engineer, but it is worth while, at least in the satisfaction that comes from a consciousness of a public duty discharged to the best of one's ability. A study of this subject has led us to adopt the graphical method of presenting everything that can be pictured. The results have been gratifying and show that in the last two years thirty projects have been handled in this manner without a single bond defeat, although ten of the projects had previously met defeat before the illustrated bond campaign had been applied. However, the greatest result of all comes in the fact of a better citizenship, a lessening of the general and typhoid death rate through better water supplies or sewerage, an awakened civic pride and increased trade flowing to the cities that have made their public improvements models in efficiency and service to the public.

The foregoing address by Mr. McDonnell was delivered before the eighth annual meeting of the Kansas League of Municipalities.

THE PIECE-WORK SYSTEM IN METER READING

By J. A. A. Beaudin of the Montreal Light, Heat and Power Co., Montreal, Canada.

The service of public utilities involves the performance of numerous routine operations in the consumer's home by various categories of employees operating individually and without supervision, said Mr. Beaudin in addressing the Canadian Gas Association recently.

The reading of meters in situ, the delivery of bills and collection notices, and the collection of arrears are a few of these operations.

Until recent years, and even nowadays, the general practice has been to remunerate employees engaged in these various tasks on a flat or fixed rate salary, based either on the hour, day, week or month, with additional privileges (in many cases) respecting sickness, holidays, etc.

Salaried Worker Leaves No Residue

This mode of remuneration makes possible the payment of wages for labor which has been only partially supplied, and since the actual supervision of his work is impracticable, the employee is tempted to take advantage of this condition occasionally, if not regularly, to limit his activities, and the means he may use to conceal his shortcomings are only limited by his ingenuity and his morality.

Furthermore, an employee working under this system of remuneration is inclined to complete indiscriminately each task as he encounters, without any regard whatever to the amount of time and expense involved—i. e., he will often devote an unwarranted amount of time to straightening out a difficulty which if reported to the office could be handled much more expeditiously and economically by an expert. In other words, a worker on a fixed salary does not by-pass difficulties—he leaves no residue.

Piece-Worker Leaves a Residue

This state of affairs has led our company to devise and introduce a system of payment on a piece or commission basis as applicable to the various categories of these employees. This piece-work or commission system keeps the employee at his work, insures the full employment of his time, limits his absences from duty, prevents the payment of unearned wages, and regularizes the output—it helps get the work done regularly and systematically, but it leaves a residue.

The piece or commission worker is interested in handling a maximum of cases in a minimum of time, so naturally the tendency is to handle the straight-going jobs and by-pass difficulties whenever encountered, no matter what the employer's interest; the employee's interest is in the opposite direction, as every stop he makes to overcome difficulties limits his wages, hence while this system has removed the necessity for outdoor supervision, it has created a demand for closer indoor supervision over the work performed, and the piece-work system must be supplemented by a faithful follow-up system of by-passed jobs, without which it would prove a failure and cease to be economical and practical.

Workers Exchange Districts

The piece-work system only works advantageously in districts where the clientele is dense or semi-dense; it is not effective in districts where the clientele is scattered. The piece-worker is entitled to a supply of work commensurate with his capacity, and his work requires to be properly sorted and routed so that he may carry it on under advantageous conditions. The employer's interest also demands this in order to keep the piece-work rating at a minimum and at the same time afford the employee an opportunity of earning a fair remuneration thereunder. Failure to give proper attention to this detail would result in the establishment of a higher piece-work rating than would otherwise be necessary.

Employees of the same category should all be on an equal footing and be given equal opportunities. They should permute periodically from one district to another in order that one and all may cover each district and the entire system in a given period. All districts do not afford similar or equal opportunities and no one should be allowed to work continuously in either a good, poor or medium district, but all should have their turn in each.

Activities Cannot Be Limited

The piece-worker, although not a tracer, a trouble straightener or a worker fitted to operate in scattered districts, must be efficient and capable of discharging his duties in a competent manner and carrying to a satisfactory conclusion all work entrusted to his care. While he is quite within his rights in by-passing real difficulties and not spending his time in conducting long searches, etc., he must positively not be allowed to by-pass for trifling causes any of the work entrusted to him.

GROUND HOGS

—because they open up trenches quickly and neatly! Look them over.

A—This is the Ladder Type P & H Excavator making a ditch thru hardpan and boulders for a contractor down in Illinois. It's a powerful machine, fabricated of steel thruout, designed for sewer digging and general heavy trenching to 20 feet in depth.

B—Is a Wheel Type P & H Excavator opening the ground for a drain pipe-line. This is the outfit for pipe-line, conduit, and farm drainage excavation. Built of steel for light weight and flexibility; digs trenches 7½ feet deep to 28 inches wide.

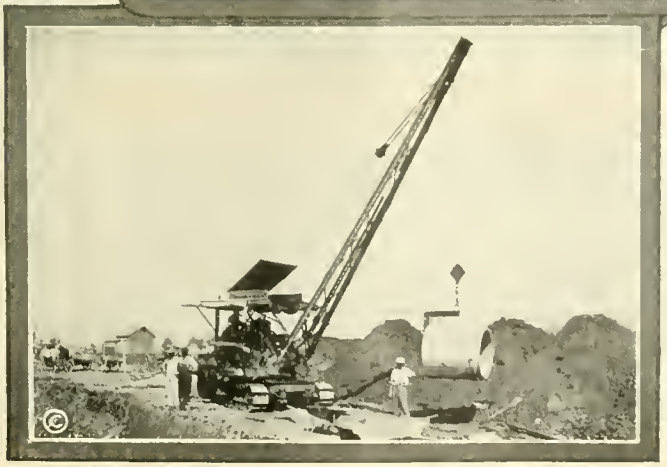
C—A machine with a multitude of uses—the 205 Dragline P & H Excavator. What it will do: Excavate open or sloping bank ditches, clean out old ditches, dig cellars and holes, strip coal, grade streets, backfill trenches, load or unload coal, crushed rock, screenings, sand or gravel, and last, but not least, it is a complete, portable locomotive crane with a lifting capacity of 3500 pounds.

D—Getting the dirt back is sometimes as troublesome and costly as getting it out. This machine makes it easy and does it in a hurry on one man's time. Just the outfit for city streets where work must be done with uniformity and dispatch. The P & H Backfiller has capacity to take care of the largest sizes of trench excavators.

You may not need P & H Excavating Equipment right now, but write for Bulletin X and keep it handy.

PAWLING & HARNISCHFEGER CO., Milwaukee, Wis.

P&H excavators, backfillers, tampers.



It is not desirable to limit the activities of a piece-worker with a view to securing work of a higher standard, as he cannot fairly be retained in service without sufficient work to keep him employed, and even if allowed to go off duty as soon as he has performed his limited task, he will work just as hastily in order to get through and go off duty, and the employer's very object—viz., to cause him to move more slowly and perform work of a better quality, will be defeated; furthermore, the resultant limitation of his earning power is likely to cause the piece-work rating to go up. An energetic piece-worker with a large working capacity will earn "record" wages when supplied with unlimited work and will indirectly contribute to the maintenance of an economical and moderate piece-work rating. Furthermore, the employee who earns large wages will have every inclination to perform his work in accordance with instructions—his very interest in his position is the best guarantee to be wished for in this connection. A proper inside supervision over the work involved in the completion of by-passed jobs, as reported by the piece-worker from time to time, affords the employer a still further protection. This inside supervision is a most important feature of the piece-work system and must be exercised with constant vigilance.

Having now dealt with the economic aspects of the piece-work system, it may be of interest to outline briefly its operation in our company, especially as applied to our meter readers.

Saturday Devoted to "Pick-Ups"

We supply "dual service" (gas and electricity) and issue part of our bills on a bi-monthly basis and part on a monthly basis. The ordinary gas and electric lighting consumers are billed bi-monthly, while the larger consumers and all electric power users are billed monthly. Our territory is divided into meter reading districts and the work distributed in accordance with schedules, so that the readings repeat themselves on about an even calendar date in each district. Twenty-two men take care of our meter reading on a piece rating per meter. These men work five days per week on regular readings; every Saturday morning is devoted to each man "picking-up" the readings which he has passed-by for various reasons during the current week. This "picking-up" work is done at the regular rating for current readings. After the completion of this "picking-up," the residue of by-passed readings reported to the office represents only such cases as present unusual obstacles. The fact that each meter reader must appropriate a certain amount of time to "picking-up" his own by-passed readings is an added protection against by-passing for trifling causes. When reading meters in a district where the clientele is scattered, the meter readers are paid an additional flat rate sum per district; this rate varies from 50c to $2.00 per meter book. A somewhat similar system is in vogue in connection with power and special clients billed monthly, as such customers are limited in number and distributed all over the system. In addition to the regular staff two special meter readers are also employed on a combined fixed salary and piece-work basis to take care of readings by-passed by the regular readers.

STORING COAL OR SIMILAR MATERIAL BY MEANS OF SCOOP CONVEYORS

An interesting application of Scoop Conveyors for storing coal is shown in the Fig. 1, illustrating five machines being used to unload coal from hopper bottom cars direct to storage pile. Four of these machines are 12 ins. wide by 24 ft. long, the other one being 12 ins. by 20 ft.

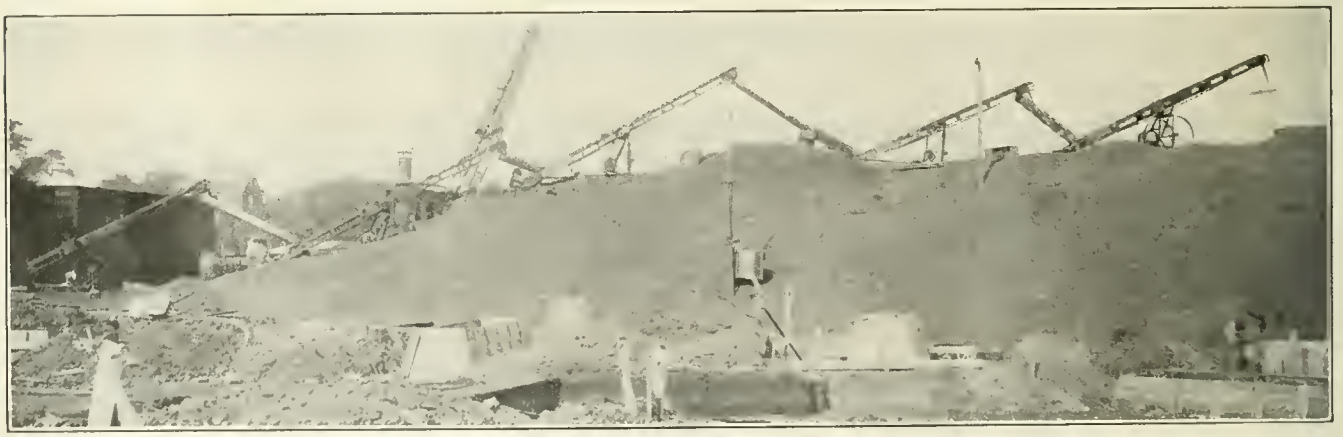


FIG. 1. UNLOADING COAL A DISTANCE OF 150 FT. WITH FIVE SCOOP CONVEYORS.

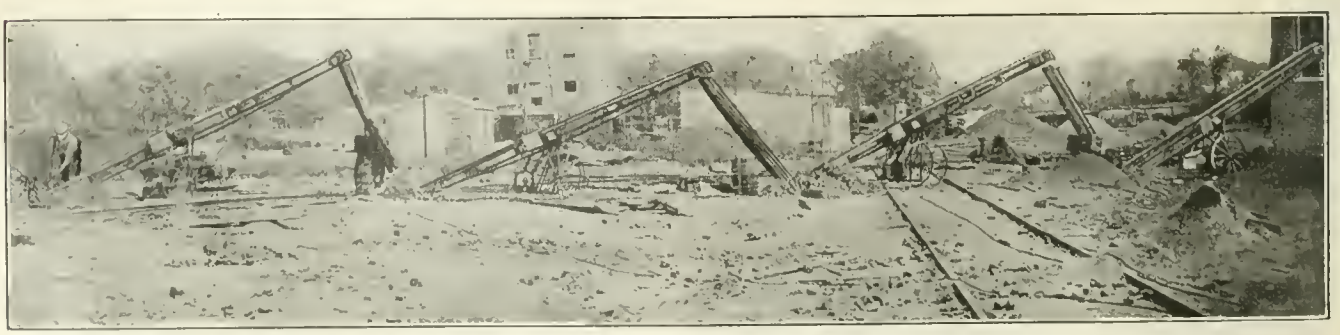


FIG. 2. USING FOUR SCOOP CONVEYORS TO CARRY COAL FROM STORAGE PILE INTO BOILER ROOM.

REO

The Coming of the Speedwagon

It may interest you to know how Reo came to build their pneumatic tired Speedwagon in the first place.

This Reo was the pioneer of its class and type—as you already know.

It looked like a daring innovation when first announced, but we were sure of its ultimate success despite the scepticism with which it was greeted by other makers and even Reo dealers.

We had been building solid-tired trucks.

Built as well as Reo knew how, still they did not live as long as we believed they should.

One day Engineer Thomas decided to equip that chassis with pneumatic tires and watch results.

As he had anticipated, that chassis outlived the others several times over.

Repairs and replacements were reduced surprisingly.

Then we decided that pneumatic tires was the answer to trucking problems as it had long since proved to be to passenger carrying.

At first, as we have said, this new Reo which we termed the Speedwagon met with scepticism everywhere.

But it soon proved its great superiority in every way.

The greater speed of which it was capable rendered it wonderfully economical as well as vastly more efficient.

And the air cushions on which it rides cut upkeep and operation cost away down.

Now—our only problem is to make them fast enough—never have been able to catch up with the tremendous demand.

Reo Motor Car Company
Lansing, Michigan

"The Gold Standard of Values"

Each is equipped with its own electric motor and can be operated singly if desired.

These machines provide a convenient, efficient and flexible arrangement. The first machine is practically self-feeding from the hopper doors of the car and the other four may be swung around at any angle to cover a wide storage area. Five machines arranged in this manner can be operated by one or two men. They can also be used to convey the coal direct from storage pile into boiler room. Fig. 2 shows four machines being employed in this manner. Where desired, one machine can be used to load an electric storage battery truck to convey the coal directly into the boiler room as shown in Fig. 3.

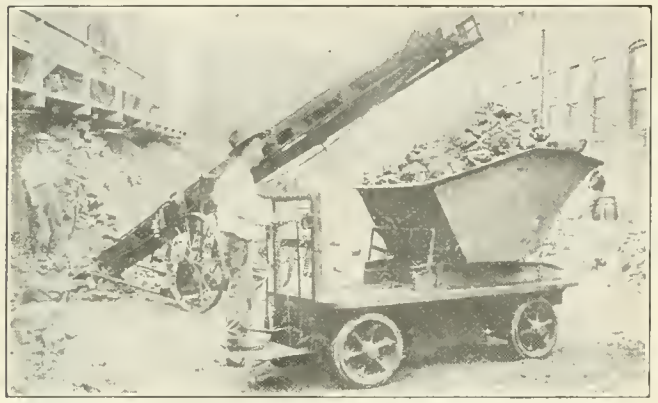


FIG. 3. LOADING COAL HOPPER ON A HUNT ELECTRIC STORAGE BATTERY TRUCK WITH A SCOOP CONVEYOR.

The advantages of using several 20 ft. or 24 ft. long conveyors are quite obvious. One long conveyor would not be equally as portable. It would be more difficult to adjust and handle and the shorter units can always be used to better advantage for general work about the plant.

A great advantage of using the Scoop Conveyor to unload hopper bottom cars is the fact that no track hopper or pit is necessary. This makes it possible to unload cars at any point along the track. To unload cars, the Scoop or feed end of the machine is placed near or under the car hopper. The hopper door is then released and the belt on the Scoop Conveyor carries the material away as fast as it flows through the hopper opening.

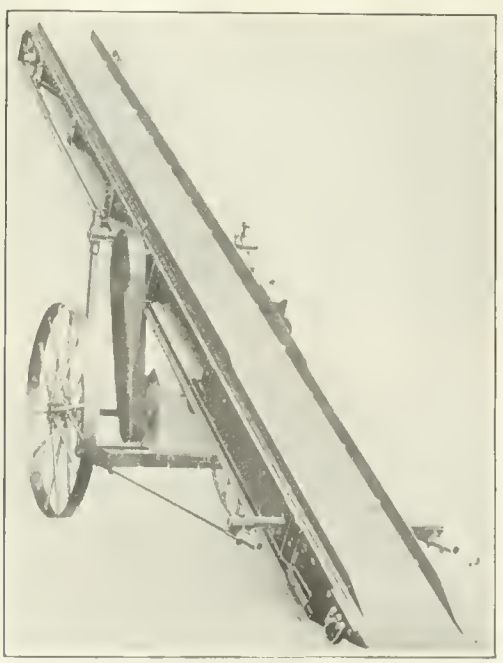


FIG. 4. SCOOP CONVEYOR FITTED WITH HIGH FLIGHT BELT.

Fig. 4 clearly shows the construction details of the Scoop Conveyor which has been previously described in the technical press. For further information, address the manufacturers, The Portable Machinery Co., Passaic, N. J.

REMOVING A CONCRETE BRIDGE BY BLASTING

An Iowa board of county road commissioners wished to demolish a concrete bridge in a short time so they employed a blaster to remove it by means of explosives. His procedure was as follows:

With an ordinary stone drill, he drilled ten holes 3½ ft. apart and extending about two-thirds through the end walls or abutments. These walls were about 3 ft. thick.

Into each hole, he packed a pound of straight N. G. 60 per cent. dynamite. An electric blasting cap was imbedded in each charge. The holes were well tamped with moist clay. They were placed just about the water level.

Holes were dug in the earth located at each of the four corners of the abutments, in each of which were loaded 5 lbs. of the same grade of dynamite. These charges were packed compactly up against the wall at its most vulnerable point. These charges were also well tamped in with clay. Another 5-lb. charge was placed down under the center of the two abutments about half way between the corner charges.

The floor of the bridge was of reinforced concrete. Four charges were placed at intervals on top of the floor. These were covered with thick mudcaps packed as compactly as possible over the dynamite. Directly under the charges on top of the floor were placed three 5-lb. charges. These charges were held in place with clay mudcaps.

This made 23 charges in all which were distributed around the different points. By means of the blasting cap wires and some copper connecting wire, all 23 charges were connected up in series and attached to a 250-ft. leading wire running to the blasting machine which was so located as to afford the blaster proper protection when the blast was set off.

In all 85 lbs. of dynamite and 23 electric blasting caps were used. The blast caused the bridge to vanish like a soap bubble. The entire cost of the work, including labor, was $29.50.

WANTED—SITUATION

Mechanical Engineer—College graduate desires position as superintendent water plant, or mechanical engineer; state institution. Address care Municipal Engineering.

CONSTRUCTION NEWS AND EQUIPMENT

CONCRETE ROAD MACHINERY AND LABOR SUBSTITUTES: SOME OF THE 1919 DEVELOPMENTS

By H. W. Eldridge, Engineer, Technical Department, The Atlas Portland Cement Co., 30 Broad St., New York.

Labor saving devices have always been studied for use on concrete road work. The use of these devices has been limited formerly to operations where economy only was considered. In the past when labor was plentiful, machinery was made use of if it could be proven to do more work at less cost than hand methods. It was simply a case of planning to use machinery if a saving in dollars and cents was shown over the use of hand labor.

FIG. 1. USE OF TEMPLATES IN OBTAINING CORRECT SUBGRADE AND IN REDUCING WORK OF FINE GRADING.

The world war in which we have taken part has changed these conditions. There is now a scarcity of labor which is recognized by all executives needing the services of common labor. This dearth of labor has naturally been strongly felt by the concrete road builders. The contractor can no longer consider the use of machinery from the economical angle alone; he must have a broader outlook and plan to make use of every new idea in machinery which is developed, because it is impossible to obtain sufficient labor to execute the work now under way. He, therefore, is forced to be inventive, and if he fails to take advantage of all of the improved methods of concrete road construction he is absolutely doomed to failure.

Nineteen-nineteen has been the biggest year in history for concrete road construction, and this boom coupled up with extreme labor shortage has resulted in some wonderfully ingenious and effective inventions and methods.

Templates

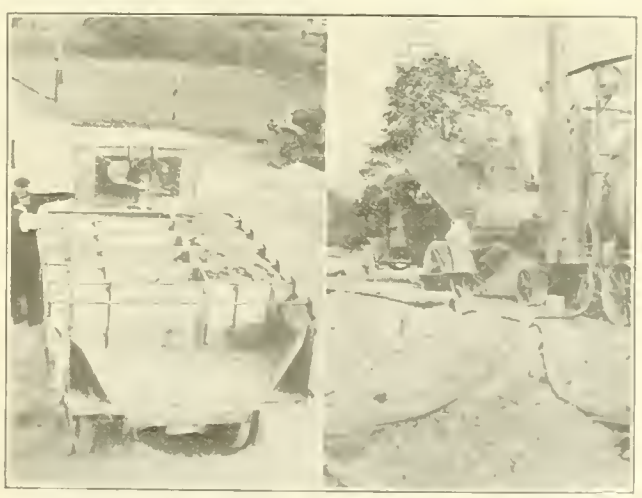
The subgrade is now given more attention than formerly and methods for fine grading are used which make one fine grading all that is necessary. In this work there are two templates used. These templates are shown in Fig. 1. Planks are notched at the ends so that when they rest on the side rails the desired grade is obtained. Iron handles are provided and two men can operate a template. The subgrade is loosened and then the templates are used. By this method a correct subgrade is obtained and the work of fine grading is greatly reduced and made more satisfactory.

Subdivided Motor Truck Bodies

Many methods for transporting aggregates from the stock pile or railroad cars to the mixer have been developed. The subdivided motor truck body has been used to advantage. The body is generally divided into five compartments, each compartment containing aggregates for one batch. Fig. 2 shows the truck ready to leave the storage yard with five complete batches of aggregates. Fig. 3 shows the truck dumping batches into a mixer skip. This method of hauling has proven economical. From 5 per cent. to 10 per cent. of the aggregates are saved which were formerly trodden into the subgrade, a more accurate and uniform method of measuring the batch is procured, and the labor on the skip end of the mixer is greatly reduced, all wheelers and shovelers being eliminated.

Combination of Industrial Batch Cars

Another method used for transporting aggregates from the storage yard to the mixer is the combination of industrial batch cars. A narrow gauge industrial track is laid from the unloading or storage yard along the shoulder of the road. The cars are each provided with two steel boxes, each box containing a complete batch of aggregates, see Fig. 4. The cars are run out alongside the mixer and the boxes are dumped into the skip by



SUBDIVIDED MOTOR TRUCK BODY FOR TRANSPORTING AGGREGATES.

FIG. 2. TRUCK READY TO LEAVE STORAGE YARD WITH FIVE COMPLETE BATCHES OF AGGREGATE.
FIG. 3. THE TRUCK DUMPING BATCHES INTO A MIXER SKIP.

NEW AND OLD METHODS OF HANDLING AGGREGATES.

FIG. 4. USE OF INDUSTRIAL BATCH CARS IN TRANSPORTING AGGREGATES FROM STORAGE YARD TO MIXER. Narrow gauge industrial track from storage yard along shoulder of road. Each car provided with two steel boxes, each box containing a complete batch of aggregates. Cars are run alongside mixer and boxes are dumped into skip by means of small derrick boom on skip end of mixer. Notice orderly appearance of subgrade and few laborers required.

FIG. 5. OLD METHOD OF AGGREGATES ON SUBGRADE, WHEELERS AND SHOVELERS. NOTE THE CONFUSION AND THE GREAT NUMBER OF LABORERS REQUIRED.

means of a small derrick boom mounted on the skip end of the mixer. This hoisting equipment is operated from a nigger head on the mixer engine. Notice the orderly appearance of the subgrade and the few laborers required. The contrast is strongly brought to mind by examining Fig. 5. This is the old method of "aggregates on subgrade, wheelers and shovelers." Note the confusion and the great number of laborers required. The Lakewood Engineering Company has been one of the pioneers in developing this type of machinery and their equipment has been used with wonderful economy and the results have given satisfaction to the engineer and the contractor. There are many more methods used for cutting down hauling expenses and handling aggregates from railroad cars to mixer. In this short article it is not practicable to go into detail regarding all of these methods, although the writer fully appreciates the utmost importance of many of the other methods.

Mixer Loaders

Where it is deemed advisable to place the aggregates on the subgrade the contractor is confronted with the problem of selecting labor saving machinery for transporting the aggregates from the grade to the mixer skip. The Koehring Machine Company has put on the market one of the best appliances for this work. This machine is shown in Fig. 6, and consists of a belt conveyor mounted on a self-propelled truck 60 ft. in length. Small steel measuring hoppers are mounted over the belt conveyor. The aggregates are dumped from the hoppers onto the

FIGS. 6 AND 7. TWO VIEWS OF THE KOEHRING MIXER LOADER IN OPERATION.

FIG. 8. USING SMALL INDUSTRIAL CAR TO HANDLE AGGREGATE.

FIG. 9. LATEST METHOD OF BELT FINISHING A CONCRETE ROAD.

Shows how and belt used on the Red Bank Middletown section, New Jersey State Route No. 4, by Heyman & Goodman, Contractors, Jersey City.

GARFORD

—*Low Cost Ton-Mile* is the basis upon which the efficiency of Garford performance is proven.

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That the United States Army has made Garford a Class A standard is another proof of Garford serviceability

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Simplex Paving Mixer

FOR fifteen years the demand for Smith Paving Mixers has greatly exceeded production. These fifteen years of practical experience and strict adherence to quality rather than quantity production, have guided the building of the Smith Simplex Paving Mixer.

"Quality-simplicity" in the construction of the Simplex fortifies you against breakdowns and delays. Fewer working parts; only eight controls, making one-man operation an actual fact; highest type of high-drum design; band friction hoist; central drum ring — these are features of superiority you will recognize in the Simplex.

And the adaptability of the Simplex Paving Mixer will satisfy you. It can be equipped with either Boom and Bucket or Swivel Chute delivery. It can be made with either Caterpillar or Wheel Traction. Derrick equipment for use with industrial car systems can be attached *to either side* of frame.

History repeats itself. There will not be enough Smith Simplex Paving Mixers to meet the demand. So do not delay. See the nearest Smith Distributor at once or write us direct and we can have our representative get in touch with you.

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Smith Non-Tilting Mixers
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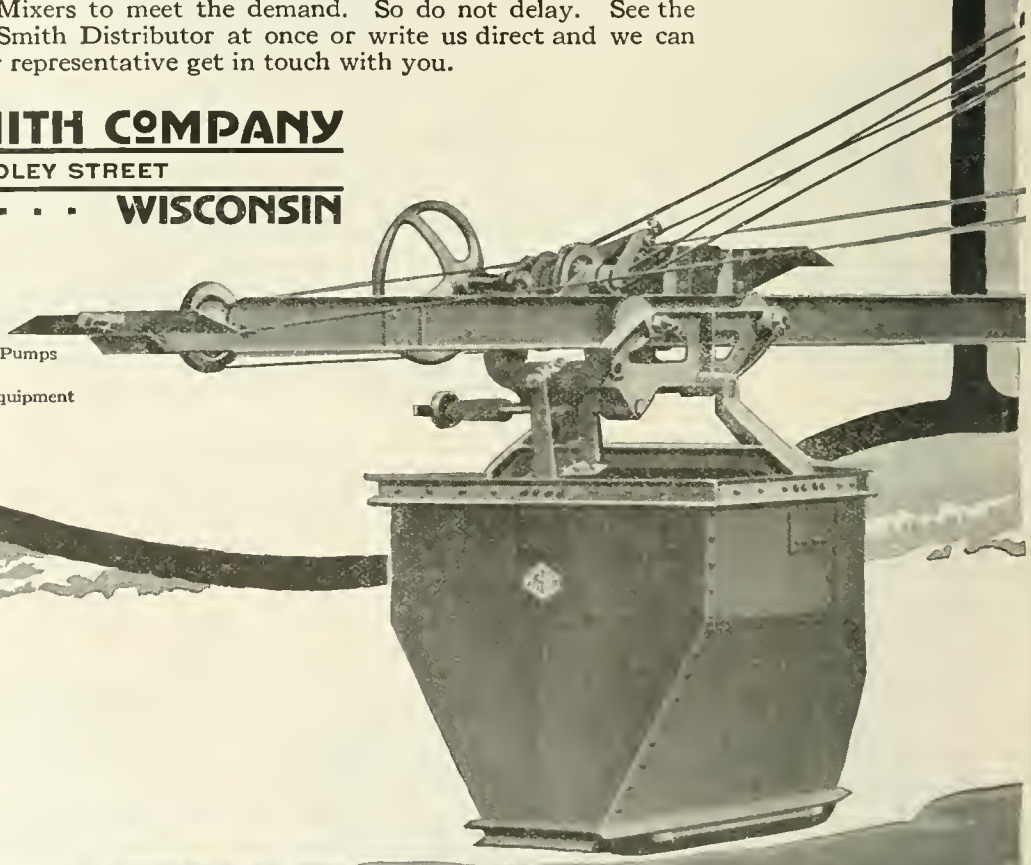

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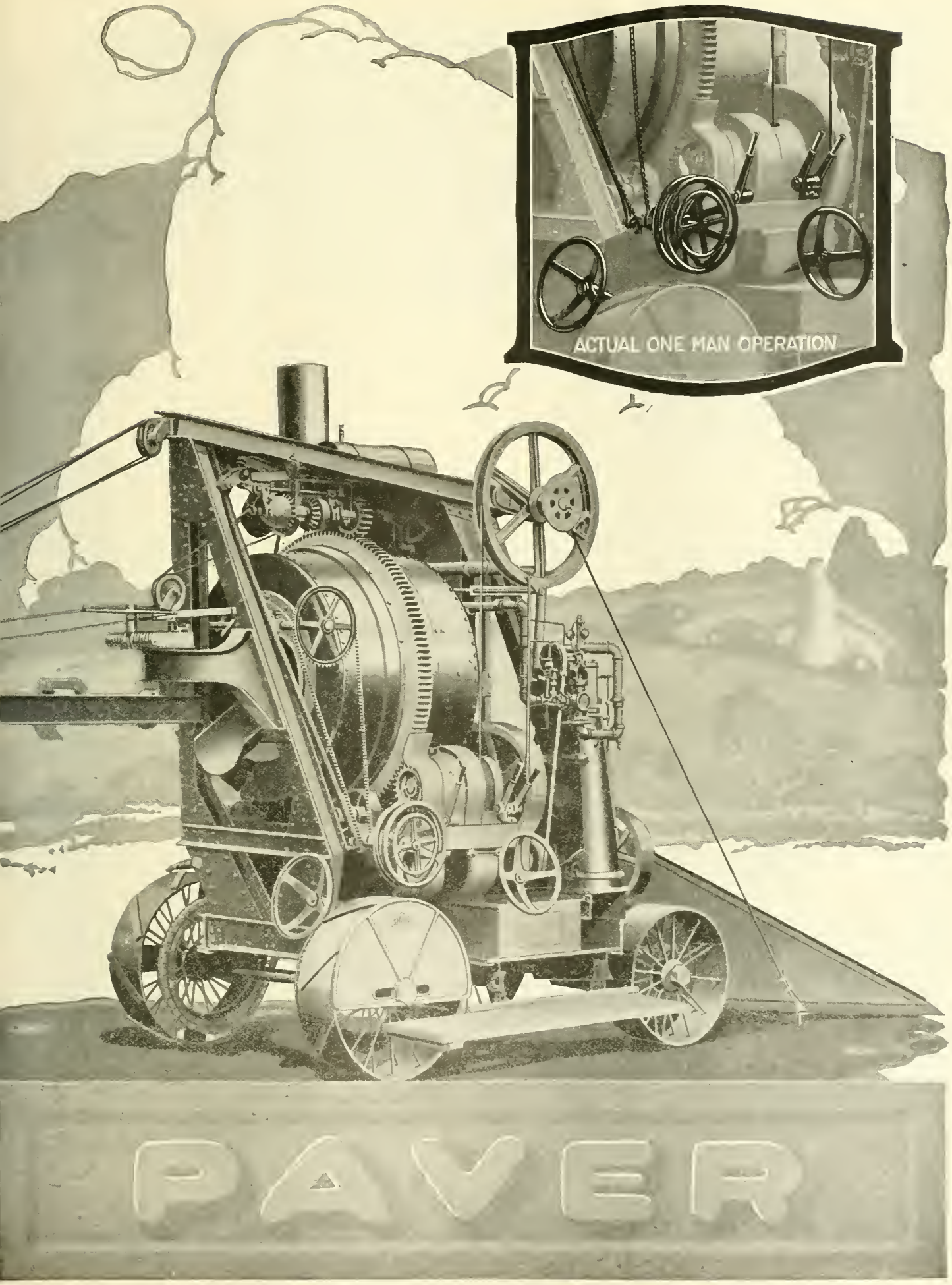

ACTUAL ONE MAN OPERATION
PAVER

FIG. 10. HEAVY STRIKEBOARD FOLLOWED BY A PLANK FOR FINAL FINISH.
FIG. 11. EFFICIENT STRIKEBOARD MADE OF CHANNEL STEEL PROVIDED WITH HANDLES.

conveyor belt and delivered to the skip. The use of this machine is advantageous as the labor is materially reduced (no wheelers needed), and accurate measurement of materials is obtained. Fig. 7 is another picture of the skip loader.

Using Small Industrial Car to Handle Aggregates

The small industrial car has been used with certain advantages for this purpose. Fig. 8 shows this method. A short piece of narrow gauge is laid on the subgrade from the piles of aggregates to the mixer skip. A small steel tipple car is loaded with a batch of sand and stone pushed by hand to the skip and dumped. It can readily be seen that shovelers only are needed and the result is that the cost of operation is very appreciably reduced.

Belt Finishing

Finishing methods have been improved. The belt and roller are still in wide use. Fig 9 shows the latest method for belting. This belt is held taut by a wooden bow. When a belt is used for finishing without a bow it has a tendency, as the belt advances along the surface of the wet concrete, to drag at the center. This of course, is caused by the adhesion of the belt to the lubricant of mortar. This dragging action causes the surface of the concrete to be ridged in diamond shapes, or as commonly called, "herring-boned." Therefore, it was considered important to provide rigidity to the belt. The bow adds sufficient tension to keep the belt in a straight line at all times and prevents curling. In this way the herring-boned surface has been eliminated and the surface obtained with the bowed belt is free from irregularities.

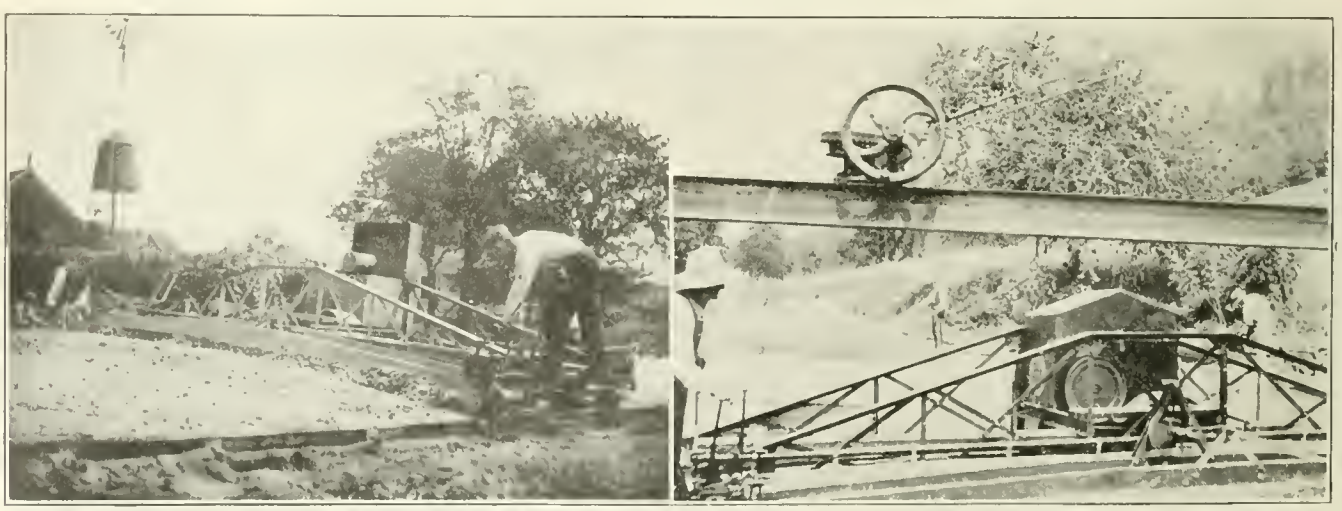
Strikeboard and Plank Finishers

On a great many road jobs the belt and roller method of finish has been displaced by the use of a heavy strikeboard followed by a plank for final finish, see Fig. 10. The strikeboard is pulled by two men in a longitudinal direction and two other men are used to produce the necessary transverse motion. This operation is followed by a plank with handles which results in a finish similar to the old wood float. A very efficient strikeboard has been made by using a piece of channel steel provided with handles as shown in Fig. 11. The striking is followed by the roller.

Mechanical Finishers

Many mechanical finishers have been put into use during the past few years. The Lakewood Engineering Company has produced an excellent machine, see Figs. 12 and 13. It is driven by a gasoline motor and rides the siderails. In Fig. 12 the rough concrete is shown at the left and the finished surface at the right. This machine strikes, puddles and finishes. The resulting surface is dense and offers high resistance to wear. Fig. 13 shows a "close up" and clearly illustrates the ease of operation.

The labor "saving" proposition on concrete road work at the present time should be considered from the



FIGS. 12 AND 13. VIEWS OF THE LAKEWOOD MECHANICAL FINISHER WHICH STRIKES, PUDDLES AND FINISHES.

labor "substitution" angle. The writer has endeavored to feature a few of the latest developments in the mechanical substitution of labor. Road construction machinery deserves wide publicity under present day conditions.

THE AUSTIN WAGON LOADER

The Austin Wagon Loader with patented self-feeding device is a distinct advance in the multiple-bucket-type of loader. Its greatest economy of operation is due entirely to the self-feeding device, which is not merely a so-called man saver, but actually does away with the necessity of keeping two men to feed the buckets, as required on other machines.

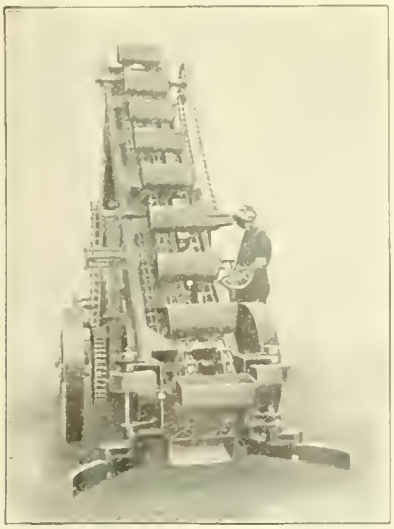
This device consists of two shovel-shaped feeders, which sweep continuously through the pile to be removed, with a range of cut 6 ft. wide, carrying the material into the bucket path and automatically withdrawing in preparation for the next cut.

The elevator proper is arranged for vertical movement, both for cutter adjustments and folding back for shipping clearances in traveling. The power plant consists of a 22-H. P. engine of marine type.

The operating machinery consists of a direct drive chain and gear transmission, giving elevator operation, and two-speed and reverse traction. The low or feeding speed is provided for use under working conditions, while the high is for traveling.

The platform is provided for the operator and all levers are easily within his reach, even the steering lever for the front wheels.

In the accompanying illustration the loader is shown



AUSTIN WAGON LOADER READY FOR OPERATION

ready for operation with the steel feeding arms extended to their outside radius of 6 ft. These feeding arms dig into the material to be loaded, gather it up and pull it into the elevator buckets. These arms will cut a swath wide enough for the machine to follow into or through the bank, and every bucket can be filled to the brim. There

For
Contractor and Road Builder
The
Williams "Twoinone" Crusher

The Williams "Twoinone" Crusher is admirably suited to the needs of the Road Builder or Contractor who must crush his material to certain sizes. This Williams "Twoinone" will crush old asphalt paving, vitrified brick paving blocks, granite blocks, limestone, niggerheads, gravel, sandstone, etc., to most any size necessary; crushing to any size between 2½-inch and ⅛-inch as desired. Capacities range from 1½ to 40 tons per hour. This Williams "Twoinone" Crusher is adjustable in more ways than one, easily inspected, or opened for renewal of parts. Its advantages are: Low horse power, high capacity, slow operating speed, low maintenance cost, adjustability, and durability.

Bulletin No. 0213 gives further details.
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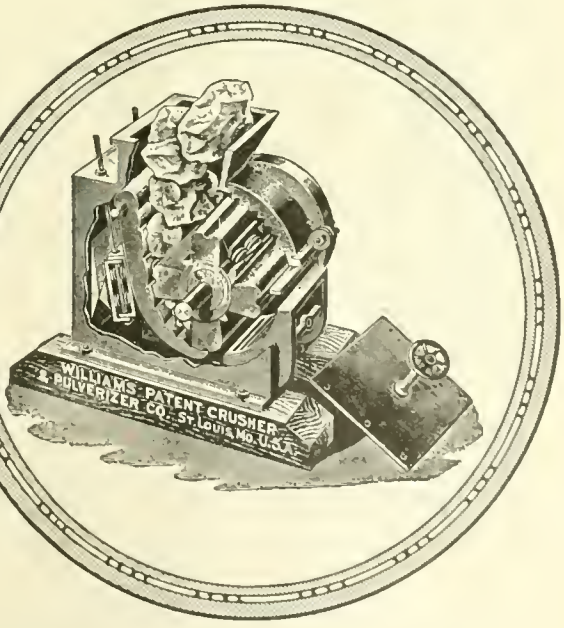


THE WILLIAMS PATENT CRUSHER & PULVERIZER CO.

GENERAL SALES DEPT.,
37 W. VanBuren St. CHICAGO.

Plant: ST. LOUIS. 67 Second St., SAN FRANCISCO.

are 22 buckets, each holding 1/3 of a cubic foot. The buckets complete 3 1/3 cycles per minute, giving the machine a capacity of 38 cu. ft. or 1.42 cu. yds. per minute. The work is all done by one or two men depending upon the nature of the material and the conditions under which it is placed.

The loader has a traction road speed of 7/8 of a mile per hour and a backing speed, which forces the digging arms into the bank, of 28 ft. per minute. Neither the bucket nor the digging arms have to be stopped, whether backing the machine or going ahead. Ample horse power is provided for this is one of the prime factors of getting good results. The loader is fitted with a spout for delivering into wagons or is furnished with a bin gate for wheelbarrow work. The manufacturers also make a discharging spout with dust screen for catching the dust when loading hard coal.

The Austin Wagon Loader is especially adapted for loading crushed rock, gravel, sand, coal, etc. It is an ideal outfit for loading material from bottom dump cars. This loader is manufactured by the F. C. Austin Company, Inc., Railway Exchange Building, Chicago. Further particulars are given in catalog No. W-L6.

FEATURES OF THE SMITH SIMPLEX PAVING MIXER

The Smith Simplex Paving Mixer presents, among other features, one very important improvement that the contractor has long been waiting for. This is the feature of convertibility which makes it possible to change the mixer from a boom-and-bucket type to a chute delivery type or vice versa.

In some districts the paving contracts call for a paving mixer equipped with the particular type of discharge favored in the eyes of the engineers in charge. This situation has not infrequently made it necessary for the successful contractor either to sell his paver or allow it to stand idle and purchase a new machine equipped to meet the specifications. In the Smith Simplex the contractor finds relief from this condition. The frame of this paver is so constructed that it can be equipped with either boom-and-bucket or chute and the arrangement is so simple that the change can be made anywhere—right on the job if necessary. This gives the Smith Simplex a range of usefulness never possible in the old style rigid one-type paver.

The Smith Simplex is the highest high drum paver on the market. The advantages of this feature are manifold. If it is equipped with chute discharge it gives the chute a pitch of from 20 to 30 degrees which makes possible a steady flow of concrete by gravity alone. Stiff or thin mixtures can be poured down the chute with equal facility and without losing any of their strength. If the paver is boom-and-bucket equipped the high drum makes possible a high boom and a long deep bucket. The boom on the Smith Simplex is 7 ft. high, allowing ample space for workmen to pass below it.

To further increase its usefulness the Smith Simplex can be equipped with either wheel or caterpillar traction. This, like the delivery, is interchangeable. The caterpillar is of the oscillating type, 18 ins. wide and extending over the rear half of the paver. The caterpillar is protected with steel treads throughout and is of an advanced, trouble-proof design.

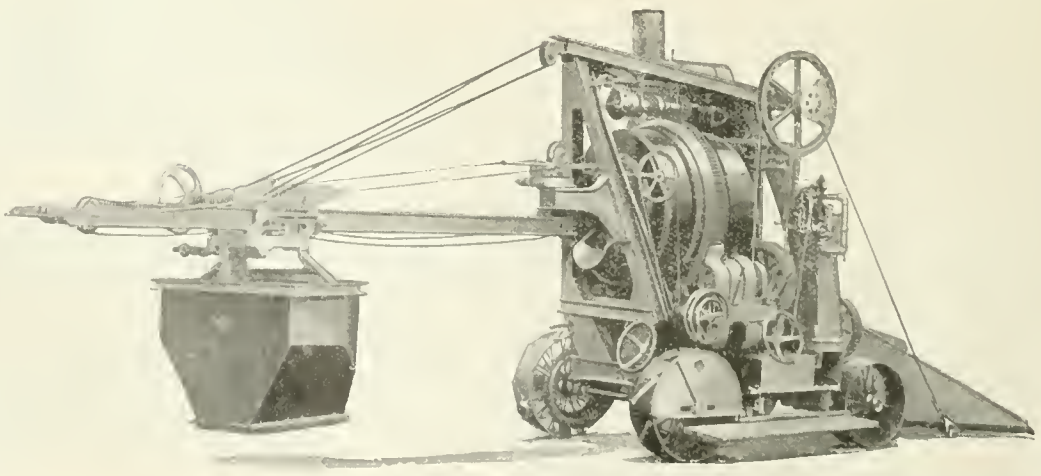
Some of the other interesting features in connection with the Smith Simplex Paving Mixer are: Actual one-man-operation, strongly reinforced frame, fewer working parts, speedy skip, quick discharge, efficient power plant, and automobile steering gear. An interesting book entitled "101 Reasons" for the Smith Simplex Paving Mixer will be sent to interested parties. Write the T. L. Smith Company, 3267 Hadley St., Milwaukee, Wis.

USE OF EQUIPMENT CUTS COST ON CONSTRUCTION OF A NEBRASKA CONCRETE ROAD

The use of equipment reduced to a minimum the cost of constructing a 6-mile concrete road from Fremont to Ames, Neb., during the 1919 season. The total contract cost of the work was $199,440.

In the construction of the road, the contractors, The Hugh Murphy Construction Company, of Omaha, provided machinery and equipment with a view of reducing hard labor and horse work to the lowest possible minimum.

Work started near Fremont, and at that place the concrete mixer moved from place to place by its own



THE SMITH SIMPLEX PAVING MIXER

power. It was a batch mixer type, mounted on caterpillar feet, provided with steam boiler engine, and water measuring device, as well as with the usual chutes and appliances for loading and dumping the mixing drum.

The water for mixing the concrete was furnished by means of a line of wrought iron pipe, leading from a group of driven wells which were operated by a 6 by 10-in. pump. The pump was mounted upon skids resting on the ground, and was belt-driven from a gasoline engine which rests on a special horse-drawn truck.

Trucks Used to Haul Materials

Concrete materials were brought to the mixer in 1-ton trucks, provided with dump bodies. Each truck brought in one load, all the materials necessary to mix one batch of concrete. These were dumped into the loading chute of the mixer. The trucks were loaded at the stock piles, located at intervals near the road, where sand and gravel had been dumped to drain after having been dredged from a subaqueous deposit. This pit was approximately 30 ft. deep, and was located near the middle of the contract.

A Gravel Loader Eliminates the Work of Ten Laborers

The trucks were loaded by a loader. It was operated by a gasoline engine which could be moved from place to place by its own power. By a shifting of levers and gears, the engine started a chain-belt elevator, which carried excavating buckets. These scooped the sand and gravel, carrying and emptying them into a hopper which served as a measuring box, delivering to each truck the proper amount of the materials for one batch of concrete. The work of eight to ten laborers was eliminated and work accomplished in half the time by the machine. An ingenious device supported the digging end of the machine upon the solid earth beneath the stock pile, preventing the buckets from digging earth and equalizing the supply of material upon which the excavating buckets worked.

Road Rails Perform Duty for Truck and for Side Forms of Concrete Pavement

The concrete was finished with a Lakewood Road finisher carried upon Blaw-Knox road rails. These rails were designed to perform both the duty of forming the side forms, for the concrete pavement, and provided a track at each side of the pavement upon which the finishing machine operated. The finishing machine shaped the

THE SCOOP CONVEYOR

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FOR STORING AND RECLAIMING, LOADING AND UNLOADING CARS, TRUCKS AND WAGONS

DOES THE WORK OF FROM 6 TO 12 MEN

AND KEEPS EQUIPMENT MOVING

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DRAGLINE CABLEWAY

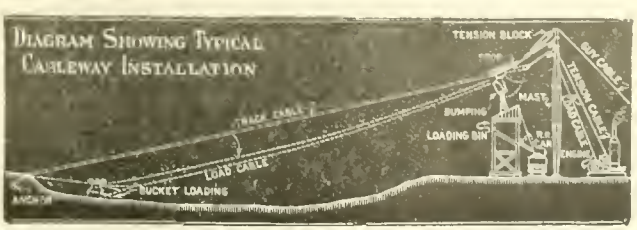
EXCAVATORS

are widely used in developing local deposits of road gravel

The cost of road construction begins — not with the actual work on the road — but with the first move which is made to get materials ready for the job.

Sand and gravel producers, highway contractors and road commissioners in all parts of the country have proved the great saving which can be affected by installing the Sauerman Dragline Cableway Excavator when materials are to be rushed for a big job of road work.

Write today for literature describing the wide adaptability of this excavator which accomplishes the DIGGING, CONVEYING, ELEVATING and DUMPING of sand and gravel all in one continuous operation, and requires but one man to operate.



SAUERMAN BROS.

1142 Monadnock Block, Chicago, Ill.

Cableway Excavators *Cableway Accessories* *Power Scrapers*

form of the finished road, tamped the concrete, rolled the surface and forced out the surplus water. It rubbed the surface of the concrete down with a strip of belting, in order to give the proper gritty finish. Between the drum of the mixer and the discharge end of the concrete chute a steel shod strike-board, rests upon side forms. This accurately gages the surface of the finished subgrade. Imperfections found in the subgrade at the time of finishing are corrected by hand labor.

At intervals, not exceeding 36 ft., the pavement is divided into blocks, separated by sheets of elastic paving joints, which extend the full depth of the surface.

Highway Trucks Haul Materials

State highway trucks, received from the War Department, were used to haul cement from the railroad to the road, where it was stored on platforms, a few hours' supply at a time. The 1-ton trucks passed on their way from the gravel to the mixer and loaded the cement sacks. Highway trucks were used to haul coal and lumber and also for the longer haul, from digging plant to the stock piles.

Roller Scraper Used in Finishing

A 10-ton steam-driven road roller was used to compact the subgrade, and for all rolling in connection with the rough grading. Fine grading was done by hand, proceeded by a blade grader drawn by horses and followed by the 10-ton roller.

Rough finishing was done mainly with Fresno scrapers, an enlarged and improved old drag scraper, with an 8-ft. cutting edge. Four horses were required to operate it. Two-horse plows and the common two-horse drag scraper were used to a limited extent in contracted spaces and narrow ditches. Blade graders were used wherever profitable, in smoothing off and leaving the smaller ridges where only small center cuts occur.

Contracts Awarded

ROADS AND STREETS

Ark., Ft. Smith—Louis Rich Constr. Co., E. St. Louis, Ill., awarded contract to construct 74 miles of highway out of Ft. Smith, through Greenwood District, at $1,400,940.

Ark., Little Rock—State Hwy. Dept. has let contracts for highway between North Little Rock and Jacksonville as follows: Camp Const. Co., Atlanta, Ga., concrete stretch between N. Little Rock and Booker; M. D. L. Cook, Little Rock, Warrenite stretch from Booker to Jacksonville; Moreno-Burkham Constr. Co., St. Louis, Mo., asphalt wrk. on N. Little Rock St., at abt. $700,000.

Ark., Little Rock—Oliver Constr. Co., Benton, Ark., awarded contracts by Little Rock & Spring Lake Hwy. Dist. for constr. of 27.5 miles roads in Pulaski and Calines counties, conc. and tile culverts, at $175,000.

Cal., Bakersfield—Rogers Bros. Co., 350 Merrick St., Los Angeles, awarded contract for constructing conc. pavement 6 ins. thick and 15 ft. wide—Fellows to McKittrick—10.683 miles, at $369,000.

Cal., Sacramento—Following contracts awarded by State Hwy. Dept.: M. D. Goodbody, San Diego, awarded contract for grading 6.6 miles San Diego county, at $55,827; Wright & Doran, San Diego, awarded contract for grading 13.8 miles, San Diego county; Casbere ranch to Tecate Divide, at $168,267; Palmer & McBryde, San Francisco, contract for grading 4 miles, Del Norte county, between Cushion Creek and Crescent City, at $32,537.

Conn., Hartford—Contracts for roads awarded as follows: Town of Canaan, 5,550 ft. gravel, Arborio county, New Haven, at $18,889; Town of Salisbury, 5,550 ft. gravel surface on slag base, to F. B. Hastings, Bridgeport, at $17,000; Town of Thomaston, 4,750 ft. trap rock, to J. H. Grosier Co., Hartford, at $32,000; Town of Watertown, 16,060 ft. concrete, to J. H. Grosier, at $120,000.

Ga., Madison—Case & Cathran, Chandler Bldg., Atlanta, awarded contract for 29,000 sq. yds. paving, 6,000 cu. yds. excav., 18,100 lin. ft. granite curb and 73,000 sq. ft. conc. walk, at $141,680.

Ga., Quitman—F. W. Long Co., Jacksonville, Fla., awarded contract to pave 5 miles Quitman-Morven Road, 9-ft. conc., $100,000.

Ga., Savannah—Lawrence Constr. Co., Augusta, awarded contract for Louisville Road (conc. construction, also includes bridges), at $373,000.

Ga., Savannah—W. T. Hadlow, Jacksonville, Fla., awarded contract by Chatham Co., Commrs., to grade, drain, pave 116,688 sq. yds. on Ogeechee Road, bridges and culverts, at $381,845.

Ga., Sylvester—Speed Parker, Inc., Louisville, Ky., awarded contract by Worth County Commrs. to construct 3.95 miles Sylvester and Albany Road, 37,333 sq. yds. Kentucky rock-asphalt over slag macadam, 6-in. base, at $100,000.

Ill., Springfield—Following contracts awarded: C. W. Clark Co., Clinton, Ind., contract for conc. and brk. rd. in Vermillion Co., at $83,994, 2 earth roads in LaSalle Co., to Powers-Thompson Constr. Co., 221 S. Chicago St., Joliet, Ill., at $134,362; 3 concrete rds., to Powers-Thompson Constr. Co., at $647,572; 2 conc. rds. Madison and Bond Cos., to Highland Lbr. & Constr. Co., Highland, Ill., at $112,410 and $110,632, respectively; 2 conc. rds. in Bond County, at $273,500 and $110,167.

Ind., Indianapolis—Central States Construction Co., Logansport, awarded contr. for constr. of concrete hwy.—Osgood to Versailles—5.574 mi. in length, at $223,151.

Iowa, Leon—Akins & Flutters, Corning, awarded contract for paving, at $201,000.

Ia., Odebolt—Western Asphalt Paving Co., 1st and Nebraska Sts., Sioux City, Ia., awarded contract for paving, at $650,000.

Kans., Ft. Scott—Dolan & Son, Junction City, awarded contract for macadamizing 4½ miles Pawnee Rd., 16 ft. wide, at $139,678.

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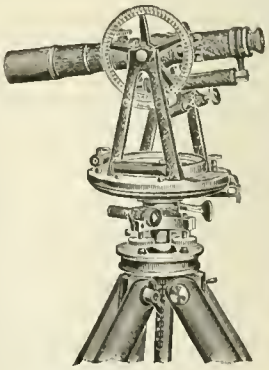

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EDITORIALS

LET US HAVE CO-OPERATION, NOT COMPETITION, BETWEEN ENGINEERING SOCIETIES

The great majority of engineers are in favor of co-operation calculated to further their non-technical interests. General agreement has been reached on this point, but there is still a difference of opinion as to procedure toward this end. Some engineers, how many we have no means of knowing, appear to favor a form of super-organization of the founder societies, or a federation of all societies for this purpose, but a very great many favor leaving the non-technical interests of engineers in the hands of the American Association of Engineers which is demonstrating its ability to safeguard those interests.

In the recent report of the Joint Conference Committee of the older societies no reference is made to the fact that the proposed work has already been undertaken, and is well advanced, by the American Association of Engineers which now has a membership larger than that of any other national society.

In deliberately ignoring the very useful work of the American Association of Engineers the Joint Conference Committee has offended many engineers and has subjected itself to a great deal of adverse criticism. Engineers have not forgotten that these older societies were deaf to all appeals for aid of the most vital character for many, many years. It is so obvious as to require no argument that the unprecedented growth of the American Association of Engineers was made possible only by widespread dissatisfaction with the cold attitude of the old societies toward the non-technical interests of engineers. There is no escaping the conclusion that the growth of the Association is a stern rebuke to the old societies and quite possibly this growth has aroused the resentment of the Bourbon element in the profession, and in ignoring the facts this element is running absolutely true to form.

This magazine is not interested in advancing the interests of any engineering society over those of another so long as the interests of engineers are not placed in jeopardy. But this magazine does believe in a square deal and we assert that the action of these older societies in ignoring the hard, conscientious and effective work of the Association is offensive to our conception of fair, square conduct. Moreover, there is nothing in the past history of these old societies to warrant any one in concluding that their conversion to liberalism is permanent. Many feel that if the American Association should quit the field today the old societies would quickly settle back in the smug and comfortable attitude they held for many decades, in effect bidding the individual engineer sink or swim, survive or perish, without so much as stretching forth a hand to help him.

The interests of these old societies have always been technical in character and they will remain largely or wholly technical, save for spasmodic concessions to liberalism. If there is among the governing class of the old societies a sincere desire at this time to help the individual engineer, in a material way, let them co-operate with the American Association of Engineers in its labors on behalf of all engineers.

KEEPING UP VERSUS CATCHING UP

Readers of engineering journals sometimes complain that successive issues contain little that is new. These friendly critics assert that issue after issue simply records facts relative to happenings in the construction field in various parts of the country; they say that what they are given from time to time is but a rehash of old stuff.

That there is a degree of justification for this criticism cannot be denied, but it is very easy for the faithful reader to be over-critical and it is still easier to miss entirely the true significance of the condition criticised.

Technical journals do not create news, they merely collect and disseminate it. When the progress of the art is rapid this is reflected in the records; conversely, when progress is slow the news value of the journals drops to its lowest point.

But the significant aspect of this matter leaves the engineer and the engineering journal in equally dignified positions. The engineer is steadily progressing and the journals of his profession follow him very closely. His progress is by evolution rather than by revolution. His improvements are gradually effected, and often his rate of progress is so slow as to be almost imperceptible to the constant observer. He is progressing steadily if slowly, however, and while it is easy to keep up with him it is very hard to catch up once you fall behind.

Men who have been in and out of engineering or engineering journalism realize keenly that the art of engineering is constantly changing for they have found that they have much ground to make up if they lose contact with engineering affairs for a year or two. The change from week to week or month to month is easily assimilated but the change from year to year is so great as to be comprehended only with a great effort.

Not a few engineers have concluded that their journals bring them so little that is new that reading is a

waste of time, only to find themselves greatly embarassed by their demonstrated ignorance of developments within the profession familiar to all who have kept up with the procession.

Thus the individual engineer must choose between keeping up with ease or catching up with difficulty or of deliberately joining the back numbers.

THE CONSTRUCTION TRIANGLE

There was a time, not so long ago, when a graphical representation of the three principal factors in the construction industry would hardly have taken the form that now comes first to mind. The three factors mentioned are the engineer, the contractor and the material man. The engineer and the contractor would have been graphically represented, in that period now happily past, by two parallel lines. These lines always "kept their distance" and never really got together except at an infinite distance from where things were happening. There can be no doubt of this part of the graph. When we consider representing the material man as a part of the same picture we are less confident of our ability to represent him in a form acceptable to all critics. Some would have represented him by a series of exclamation points, undoubtedly, and others by a question mark large or small as individual opinion dictated. Some would have represented him by a line crossing the other two at right angles, while still others would have made his angles of intersection at once obtuse and acute.

But now this most interesting and serviceable graphical representation of the three factors takes the form of a triangle, and an equilateral triangle at that. In the presidential address at the recent annual convention of the American Road Builders' Association, the word "us" was used to include the engineer, the contractor and the material man by a president who is the state highway commissioner of one of our greatest states, a man who has come to think of these three elements jointly.

The triangle, be it remembered, is the symbol of strength and rigidity. It is the truss element. Let us make it truly symbolical.

THE DICTATED ARTICLE

At this time when engineers are so busy it is well to consider the merits of the dictated engineering article. In this period of high pressure activity in the construction industry there is little time for composing articles in ornate diction and in literary style. Unless the engineer resorts to the dictated article, therefore, he will fail to make the contributions to the literature of his profession that he should make. He is very busy because he has extraordinary opportunities to achieve developments in the practice of his profession, and the great trust imposed in him by the public carries with it the obligation to report for the use of others the knowledge he gains.

It is often stated that the set papers delivered at conventions are of less interest and value to the practical man than the discussions inspired by the papers and this is quite true. The long, set paper is comparable with the carefully written article and the short practical discussion is comparable with the dictated article. If these discussions by men unaccustomed to public speaking are so useful to the profession it follows that the same men, in the easier atmosphere of their own offices, could dictate short articles, or discussions if you please, that would be even more helpful to other workers in their field.

With the unprecedented opportunity now enjoyed by every engineer to try out his theories in practice he should observe many things worthy of record. We urge that he use the dictated article to report his observations and impressions. If the name "article" sounds too formidable why not say discussion or letter? Engineers are as quick to write letters as they are slow to write articles, so why not write "letters to the editor" instead of articles? It is assumed that letters are dictated, and it is generally recognized that a letter does not necessarily represent the maximum skill of its writer in the selection and arrangement of words. Thus the author of a letter need give little thought to possible criticisms of his composition. Give the editor the naked facts and figures and leave it to him to clothe them as their needs may require.

Unless workers in the construction field adopt these suggestions in principle and act on them we are all going to lose a great deal of immediate value. Let us tell our stories while we work, not afterwards. Let us exchange information while it possesses maximum usefulness, rather than record ancient history after the next industrial depression is upon us.

CO-OPERATION IN THE HIGHWAY FIELD

A splendid spirit of co-operation is beginning to take form in the highway field. Never before have engineers, contractors and material men regarded each other with so much toleration and esteem. Each class realizes it can do nothing by itself, that team-work is required to protect class and individual as well as public interests. Engineers have come to realize that they should co-operate with the contractor as well as to sit in judgment on his work. This changed attitude is reflected in the support the cost plus form of contract is receiving from engineers. Contractors must be fairly dealt with and protected against hazards beyond their control. We anticipate that before long cost plus contracts in some improved form will be legalized in the public works field. Engineers are now getting something of the contractor's viewpoint and see his side more clearly than ever before.

This spirit of toleration is due in part to necessity, lest the contractor become extinct and to the abundance of opportunities for all, but it is due also to the normal development of the industry.

SERVICE THE FINAL TEST OF QUALITY OF ROAD STONE

By H. Eltinge Breed, Consulting Engineer, 507 Fifth Ave. New York City

There is shortage of materials for highway work. Yet certain traditions prevent our utilizing all available sources. With road building still so young a science, it is startling to discover the large part that dogma is playing in its development. Startling on the one hand because we have liked to believe that we were progressing in accordance with scientific methods of investigating and experiment, and it is disconcerting to find ourselves prejudiced by empirical judgments—startling on the other hand because we find that the very definiteness and apparent accuracy of research may give rise to delusive opinions. The matter has been brought forcefully to my attention in respect to the qualities of stone.

Limitations of Rattler Tests

We have judged stone by the rattler test and rated it according to the French coefficient of wear. The harder stone with a higher coefficient was adjudged the best, because it offered the greater resistance to the wear administered by the rattler test. By analogy it was assumed that it would likewise offer greater resistance to the actual test of service under traffic. It was assumed, without proof, that wear upon stones in a pavement would be relatively the same as was the wear upon stones in a rattler. This assumption I believe to have been unsound, because it ignored this fact:—stones in a rattler are a loose aggregate; stones in a pavement are a more or less compact mass.

It is obvious that the looser the type of pavement the more closely will the wear upon stones under actual traffic approximate the wear in the rattler test; that is, in the looser types, each stone, like the stones in the rattler test, is a unit offering individual resistance to the friction of traffic upon it. In so far as each stone in the pavement is a separate unit the accuracy of the rattler test may be accepted in determining the standard of stone to be used.

Rattler Test Not Sound for Rigid Types of Pavement

But in those rigid types of pavement where the stones, far from being separate units, are simply parts of a compacted mass, then, I believe, the rattler test is not sound, its apparent accuracy is misleading, and the conclusions we have drawn therefrom false.

Because in the rigid types of pavement it is not the stone alone, it is the whole pavement that offers resistance to traffic. It is not the stone, but the lack of mortar strength that causes disintegration. The stone is merely one elemen in the whole. True, if it were the weakest element, it might be held responsible for failures. This possibility has been safeguarded by repeated experiments in both laboratory and field which have demonstrated that the wear of stone with the French coefficient of from 6.5 to approximately 7.5 is equivalent to the wear of the matrix of a concrete pavement in service. To use stone of a lower coefficient would be an unwarranted risk. On the other hand, to use stone of a much higher coefficient is unnecessary, often expensive, and, I believe, sometimes detrimental to the pavement.

Stone has been the determining factor in the success of so many types of pavement, that when we come to the rigid type known as the concrete pavement we failed to realize that its importance had relatively lessened. We did not see it in relation to the whole.

Quality of Stone in Concrete Road

No concrete pavement is stronger than the matrix that holds it together. When the matrix disintegrates the pavement disintegrates. Every failure in concrete roads has been traceable to dirty aggregates, faulty mixture, or wrong methods of laying. Never once in my experience have I found the qualities of the stone itself to blame, i. e., where it had a French coefficient of 6:5 or better. This fact taken in conjuction with the remarkable success of concrete roads built with stone of a low French coefficient led me to consider afresh the problem of the serviceability of stone.

Rattler Test Not a Positive Determinant

I wondered whether we were not laying too much stress upon the value of the rattler test as a positive determinant. Should it not be regarded rather as a deterrent from using materials that are flagrantly below the standard? How far can you really gage the strength of a road by the strength of each of its component parts? In roads like the water bound macadam, very adequately, because in each individual part there is the individual resistance to traffic wear. In respect to a concrete road, not at all, because the resistance to traffic is determined by the whole structure and not by any one element on it. The relation of the stone to the strength of the road is the sum total of the resistance to traffice that the road will offer. If the stone is harder than the matrix, the wear is going to be uneven. This is demonstrable in many of our concrete roads. The sands and cements have worn down from the surface faster than the stone, and roads have become roughened under heavy traffic. Then there is always danger that these slightly uneven pieces of hard stone may be chipped out and increase the disintegration of the pavement. The softer stone shows a more uniform wear; that is, it rubs down with the other elements in the pavement and the whole road is kept in a smoother condition by its use. The final test of any piece of pavement is wear under traffic. The greatest destructive factor upon a pavement is impact whose force is intensified by uneveness.

Specific Examples

A piece of concrete pavement that I have had under inspection refutes the idea that all stone shall be deemed excellent for all purposes in proportion to its French coefficient. The section I have specially watched was completed in 1914—five years ago, in proportion 1 : 1½ : 3 of standard cement, clean Long Island sand, and Tomkins Cove limestone with a French coefficient of 7.1. It is part of Highway 5301 in Suffolk County, New York. Here are the locations at which this stone was used. From Station O-O to Station 245-O and from Station 265-O to 273-O section 19; from 12-O to 76-O on section 20, approximately six miles in length.

The condition of this pavement on October 9, 1919 showed the surface wear amounting to less than ¼ in.—hardly enough to obliterate the broom marks. There was no wear at cracks, none at joints, a smooth uniform surface, and a mosaic appearance. This in spite of the fact that it has stood the severest traffic stress under impact from very heavy and very swiftly moving vehicles.

An actual traffic census has not been taken on the six

miles under examination, but the traffic density may be estimated by the census that has been taken on the two roads contiguous to it. It shows on road 5488 in 1916 as follows:

Total horse drawn traffic.....343 tons daily
Total motor drawn traffic.....3090 tons daily
Total motor truck traffic..... 936 tons daily

It shows on road 793 in 1916 as follows:

Total horse drawn traffic.....187 tons daily
Total motor drawn traffic.....782 tons daily
Total motor truck traffic.....453 tons daily

This traffic has been immensely increased since 1916 by traffic going to and from Camp Upton, to which our road is a feeder.

This specific instance is supported by 29.04 miles of pavment built in western New York from Buffalo limestone with French coefficient of from 6.5 to 10. They have been laid about the same length of time as the road we have cited, and show the same uniform wear.

The following is a tabulation of this work:

Road No.	Miles	High & Low Coefficient as Shown by Test	When Constructed
1214	5.89	(9.3 to 7.7	Part built in 1915
		(10.5 to 5.7	Part built in 1916
5434	2.01	7.4	Part built in 1914
5453	3.61	7.4	Built in 1914
5217A	6.23	(10 to 8	Part built in 1915
		(10 to 7.6	Part built in 1915
5245A	5.95	10 to 7.6	(Part built in 1915
			(Part built in 1916
5263A	5.35	10 to 7.6	Part built 1915-16-17

Value of the Impact Test

If we regard as of only partial value the laboratory tests upon the component parts of the concrete pavement, it becomes more than ever necessary to have a test for the pavement as a whole which shall serve as a standard of measure. This, I believe, is found in the impact test. It takes a piece of finished concrete as a whole and pounds upon the surface of it in a way that approximates the actual wear of traffic. And it proves beyond question that while the limestones, or other stones with low French coefficient show a slightly greater loss in weight than the very hard stones, yet this loss, in the final wear upon the pavement, is more than compensated by the greater uniformity of surface wear. These experiments were carried out by Mr. Mattimore in the New York State Laboratory in Albany, and were described by him, with graphic illustrations in an article entitled, "Wear-Resisting Values of Various Aggregates for Concrete Roads Indicated" found on page 861 of the Engineering News-Record of May 2, 1918.

Thus scientific research and experiment seem to corroborate the conclusions suggested by experience;—we can no longer generalize safely about all stone; we must consider a particular stone in relation to its particular function in a specified type of pavement. And the concrete type is better built with stone whose wearing quality is most nearly commensurate with that of the matrix. That is, with stone with a French coefficient of from seven to nine.

HIGHWAY WORK IN NEW ENGLAND IN 1920

The following data on highway work in New England in 1920 is given by Col. Wm. D. Sohier, formerly chairman of the Massachusetts State Highway Commission:

I am showing the amounts of money that will be available in the various New England states during 1920 for highway work: (The amount available in Connecticut is given as for two years, 1920 and 1921, this including Government Aid, was $9,640,000 for construction and maintenance; I have divided that amount to get an average for one year.)

MONEY AVAILABLE AND HIGHWAY WORK TO BE DONE IN NEW ENGLAND IN 1920

State	Miles of State Highway Construction & Reconstruction	Cost	Miles Maint.	Cost
Maine	150	$4,500,000	4,500	$800,000
State Aid	100-125	1,250,000	....	.....
New Hampshire	100	1,250,000	1,500	750,000
Vermont	75	1,323,000	1,518 patroled	
(4,339 miles maintained under State supervision and with State help)			2,821	450,000
Massachusetts—				
S. H. & Fed. Aid....	100-125	3,300,000	2,286	1,200,000
State Aid	100	1,500,000	....	.....
Reconstruction	60	1,250,000	....	.....
Poor Town Roads....	.....	.....	5,500	450,000
Rhode Island	30-40	1,300,000	333	350,000
Connecticut	110*	3,845,000	1,627	2,000,000
	855-915	19,518,000	20,085	6,000,000
		6,000,000		
Total available		$25,518,000		

*Estimated.

BUILDING STORM WATER SEWERS IN HAMILTON, OHIO

By Roger B. McWhorter, Assistant Division Engineer, The Miami Conservancy District, Hamilton, Ohio

Three concrete, storm water sewers have recently been built in Hamilton, Ohio, by the Miami Conservancy District, as a part of the local flood protection work. The sewers total 4,160 ft. in length and are from 4 ft. to 5 ft. 8 ins. in size. The largest of these sewers is located on Buckeye St. Another is located on Wood St. and the the third is located on Front St. The following description by Mr. McWhorter of these sewers and their construction is from The Miami Conservancy Bulletin for December, 1919.

The Buckeye Street Sewer

There is an area in the northeast part of the city from which the storm sewers drain into the tail-race, which until recently, flowed northerly to Old River. This tail-race was a part of the Hamilton and Rossville hydraulic and was abandoned for power use with the other parts inside the corporation limits. Its outlet was closed by the Old River improvement, and the sewers that empty into it are now served by the Buckeye Street intercepting sewer, which connects with the tail-race. The maximum flood stage to be expected at Buckeye Street is elevation 589.5 ft., or about 3.5 ft. lower than at the tail-race outlet, a noteworthy advantage of the new location.

This sewer is made of reinforced concrete, horseshoe shaped, inside dimensions 5 ft. x 5 ft. 8 ins. and is 1,868 ft. long. Figure 1 shows its cross-section and design of forms in detail. It connects with the tail-race 300 ft. east of Fourth Street and runs westerly, 9 ft. north of the south curb, to the river. The elevation of the flowline at the connection with the tail-race is 577.0 ft. There is a change in grade at Third Street, 740 ft. from the tail-race. Above

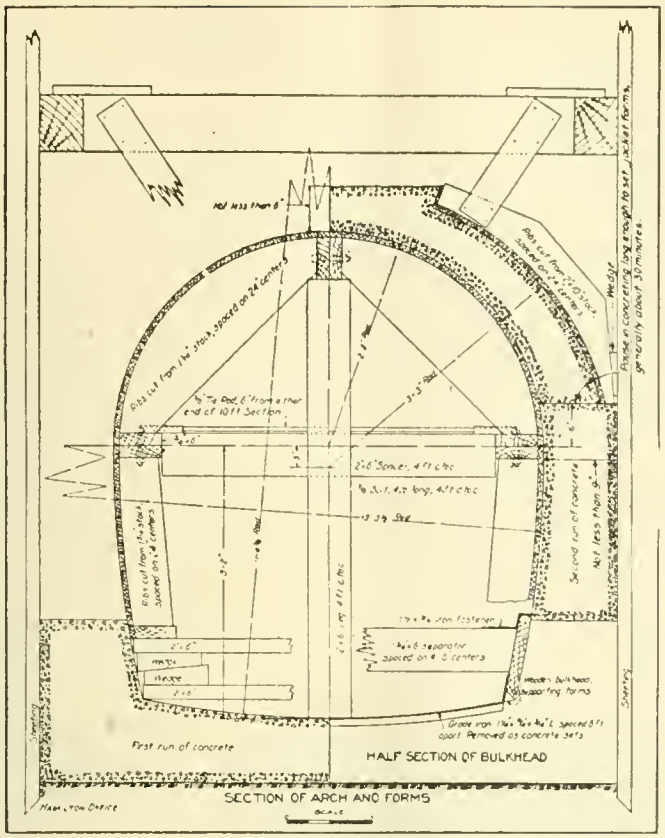


FIG. 1. CROSS SECTION OF BUCKEYE STREET STORM WATER SEWER, HAMILTON, OHIO.

Cut also shows design of forms in detail and methods employed to hold them in place, also shows sequence of concreting operations.

this point the grade is 0.45 percent and below it 0.40 percent. The sewer has an inside sectional area of 24.5 sq. ft., and is capable of discharging about 200 cu. ft. per second. There is a gate manhole about 70 ft. back from the outlet, in which a floodgate will be operated during extreme flood stages. A standard manhole was provided at each street intersection, through which there can be no overflow, even with the floodgate out of commission, as the street surface is from 6 in. to 6 ft. above the maximum flood level. The gate will protect the ground surface from flooding should the river level approach the top of levee, which at Buckeye Street, is 4 ft. above the estimated maximum flood level.

Excavation—The excavation was begun at the lower end of the trench, the plant used consisting of an electrically operated traveling derrick, fitted with a ¾ yd. clamshell bucket, and mounted on a 28 ft. gage track, straddling the ditch; one 24 in. gage Plymouth gasoline locomotive, four 1½ yd. rocker dump cars, and 420 ft. of track laid with 30 lb. rail. The track was placed alongside the ditch at a convenient distance for the derrick to load the cars. The amount of material by which the excavation exceeded the backfill was wasted on the river bank south of the outlet to be later removed by the large river excavating machine. The depth of cut ranged from 14 to 24 ft.

A stratum of hard, tough, blue clay, varying in thickness from 4 to 7 ft., and lying from 8 to 10 ft. below the surface, was found, extending from the outlet to a point some 450 ft. up the trench. This material was difficult to remove and impeded the progress, increasing the expense considerably during the first month or so. Dynamite was used, but not very effectively. The clay proved to be too soft to blast and too hard to be handled satisfactorily by the clamshell. West of Front Street the material other than the clay consisted of cinders and loam. From Front Street to Fourth Street, 3 or 4 ft. of surface loam was underlaid by clean gravel and sand, suitable for use in concrete.

Because of the nature of the soil and the depth of the trench continuous sheathing of the sides was necessary. Fig. 2 shows the method of shoring the trench.

A street railway line runs up Third Street to Black Street, under which the sewer trench was passed, thereby necessitating an interruption of the service north of Third Street. As the patronage on that part

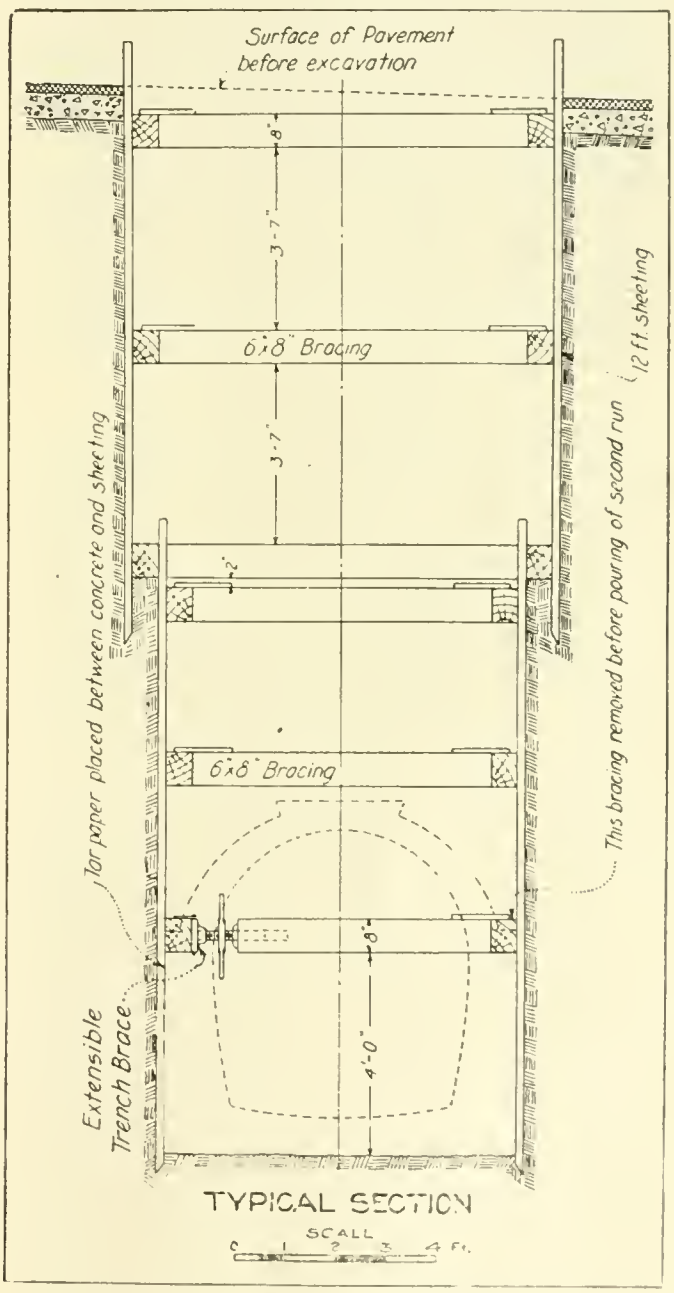


FIG. 2. METHOD OF SHORING THE TRENCH FOR THE BUCKEYE STREET SEWER, HAMILTON, OHIO.

of the line is small, except during the early morning and late afternoon hours, the service was suspended during the day for the few days the derrick was working over the track. Provision was made to pass the cars up to 8:00 a. m. and after 4:00 p. m.

The double track main line of the Baltimore & Ohio Railroad crosses Buckeye Street at Fourth Street, and the sewer was carried under these tracks by means of a tunnel. The tunnel was 48 ft. long, of cap and leg construction, sheathed overhead and on the sides. The

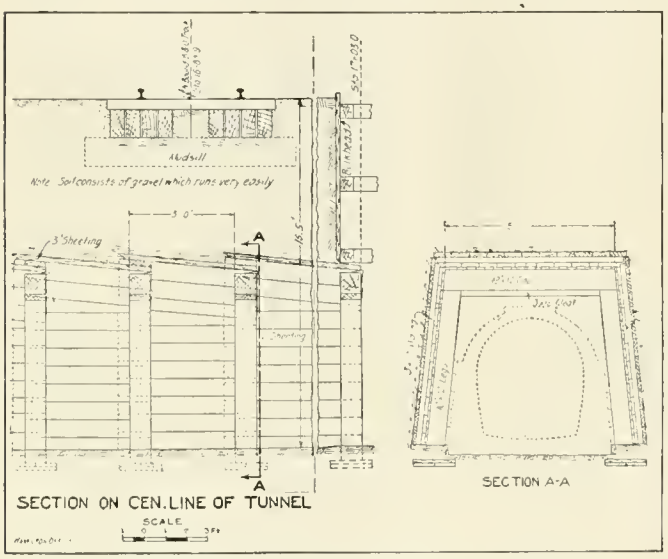


FIG. 3. TUNNELING UNDER THE B. & O. R. R. AT HAMILTON, OHIO, IN STORM SEWER CONSTRUCTION.

sections shown in Fig. 3 give an idea of the manner in which the tunnel was built. To guard against possible settlement of the tracks four 8 in. x 16 in. stringers, 30 ft. long, were placed by the railroad company symmetrically under each rail, each resting on four 16 in. square mudsills, one placed on either side of the trench and one at either end of the stringers. After completing the sewer through the tunnel the remaining space was packed full of loam sand, care being taken to leave no voids. The temporary timbers under the tracks were then removed, and the original condition restored.

Concrete—A ½ yd. Smith portable tilting mixer and wood chutes were used for mixing and placing the concrete. The "trench run" material supplied both the fine and coarse aggregates, as frequent screening tests made throughout the work indicated that no screening was necessary. These tests, through ¼-in. screens, showed the ratio of gravel to sand, with only one exception, to range from 2½:1 to 2:1. Sufficient cement, as determined from the tests was used to maintain a ratio of 1:2 between cement and sand, and enough water was used to make a mix that would move down the chutes with slight assistance from a hoe or shovel. Both water and aggregates were heated during freezing weather, and the fresh work was covered with tarpaulins under which salamanders were placed. However, the winter of 1918-19 was very mild, and heating was necessary in only a few instances. A layer of tar paper prevented the concrete from coming in contact with the sheeting.

Fig. 1 shows in detail the forms used, and the methods employed to hold them in place. It also shows the sequence of the concreting operations. Forms were left in place till the second day after concrete was placed, usually from 40 to 48 hours.

Backfilling—The backfilling was done by shifting the dinkey track so that the cars could be dumped into the trench. A stream of water was played upon the fill constantly and lumpy material was not allowed to remain unpuddled. The backfilling was kept close up with the concrete, and the sheeting was pulled soon after the trench was filled. A heavy timber "horse" and a block and tackle rig were used for this purpose, the power being furnished by either the gasoline locomotive or a 5-ton motor truck. Voids left by the sheeting were flushed with water. Elevations taken in sanitary sewers near the trench and parallel to it showed no settlement. However, it was necessary to remove parts of the pavement adjacent to the sheeting, because of the poor condition of both the concrete base and the wearing surface.

The street was repaved about three months after the backfilling was completed. A 10-ton road roller was

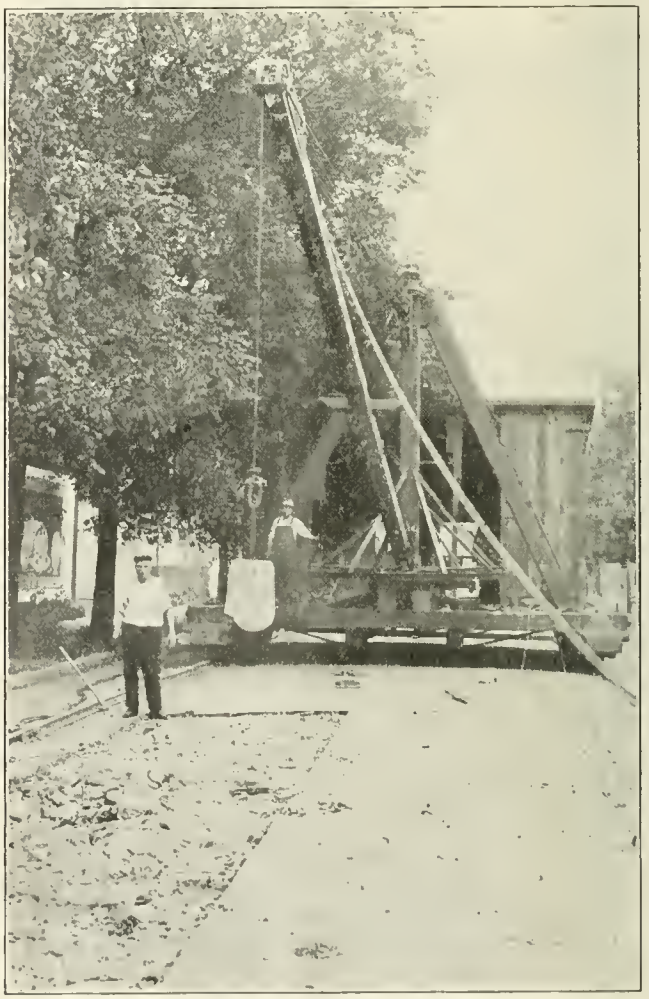


FIG. 1. BREAKING CONCRETE PAVEMENT BASE, ON SEWER CONSTRUCTION, HAMILTON, OHIO.

The 6-in. concrete pavement base on Wood Street was broken by dropping a 1-ton hammer on it, worked by the excavating derrick, thus averting the laborious process of breaking it with a sledge. At Buckeye Street the concrete base, owing to its inferior quality, was readily removed by the clam-shell bucket.

used to compact the sub-grade, upon which a 6 in. base of 1:2½:6 concrete was laid. The asphalt was placed by the Andrews Asphalt Paving Co. of Hamilton.

The sewer was begun in August, 1918, and completed in April, 1919. The quantities were as follows: Earth excavation 11,453 cu. yds.; rock excavation, consisting of old foundations and concrete base, 303 cu. yds.; concrete 1,133 cu. yds.; reinforcing steel 79,600 lbs.

Wood Street Sewer

In the central part of the city there is an area of about 132 acres, which until recently was served by a storm sewer on Wood Street discharging into the river north of the Columbia bridge. This sewer has a manhole at each street intersection, and as the surface of Wood Street, west of Second Street, is below the maximum flood stage to be expected (elevation 586 ft.), it was necessary to place a floodgate at its outlet. A reinforced concrete circular storm sewer, 4 ft. in diameter and 1,588 ft. long, has been built on Wood Street, from Second Street to the river, parallel to the old sewer, to drain by gravity during extremely high river stages the 106 acres of the aforementioned area lying above elevation 586 ft. The desired condition was obtained by building a tight sewer and connecting it with the old sewer at the existing manhole at Second Street, leaving a dead end on the old sewer at which a standard manhole was built. The elevation of the flowline at the connection is 580 ft. (the street surface here being elevation 590 ft.) and the new sewer is built on a grade of 0.6 percent, having a capacity of a little over 100 cu. ft. per second. On the river side of the levee the old sewer was connected with the new one, a gate manhole being built in the old sewer at the levee. Thus for all ordinary stages of the river the 26 acres still served by the old sewer are drained through the outlet of the new sewer. There are no manholes or other openings in the new sewer except a standard manhole at the center line of the levee, the top of which at elevation 589, is flush with the top of the levee. West of the levee the sewer is of horseshoe shape, on a grade of 9.7 per cent. As precaution against underwashing the outlet structure and the horseshoe portion of the sewer were built on timber piles. The piles under the outlet structure range from 23 to 28 ft. in length, and the balance from 15 to 20 ft.

The excavation, concreting and backfilling operations were practically the same as at Buckeye Street, the same plant being used. The depth of cut was 18 ft. at the outlet, and ranged from 7to 10½ ft. on Wood Street. The deepest excavation was about 6 ft. below the river level at that time, necessitating pumping, a 4 in. centrifugal pump driven by a 25 h. p. electric motor being used. Wood Street is paved with asphalt on a concrete base east of Monument Avenue, and to facilitate its removal the concrete was broken, by dropping a 1-ton hammer on it by the derrick as shown in Figure 4. The asphalt was cut by an improvised rolling disc, placed on a pin between the timbers, and wedged under the derrick.

The street has not, as yet, been repaved. This will be done in conformity with the original specifications.

The job was begun April 9, 1919, and completed July 31, 1919, the quantities being as follows: Earth excavation 4,600 cu. yds.; rock excavation 186 cu. yds; concrete 665 cu. yds.; reinforcing steel 21,700 lbs.; timber piles 900 lin. ft.

Front Street Sewer

There is an area lying between Wood Street and South Avenue that has been served by a storm sewer that runs southerly on Front Street to a manhole at the old Crawford's Run crossing, thence westerly in an open channel to the river. A sewer connecting the

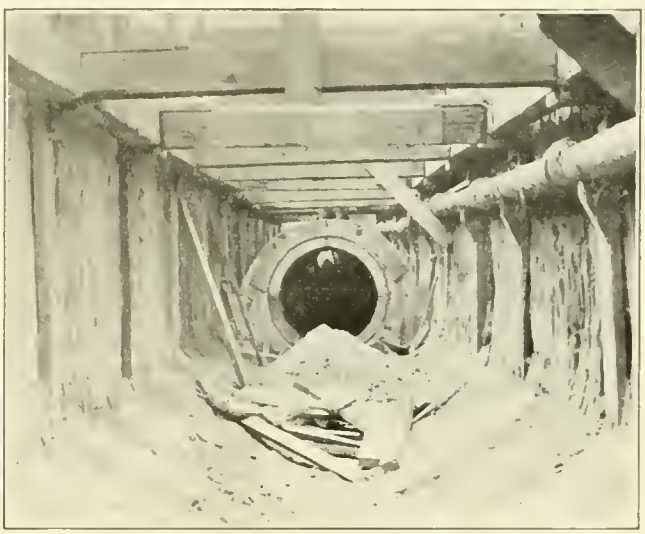


FIG. 5. STORM WATER SEWER TRENCH IN WOOD STREET, HAMILTON, OHIO.

The fine loamy sand on this portion of the sewer required but little shoring. The water main seen against the bank was successfully jacked over from the middle of the trench without interrupting the water service. It was necessary to recalk only a few of the joints.

manhole with the low ground east of Front Street serves the old Crawford's Run drainage area. The outlet was closed by the recently constructed levee, and a plain concrete circular sewer, 4 ft. in diameter and 704 ft. long, has been built to drain the areas mentioned, which total about 112 acres. This sewer connects with the manhole referred to, and runs southerly along Front Street to South Avenue, thence westerly to the river. The maximum flood stage to be expected at its outlet is elevation 585 ft. The elevation of the flowline at the upper end is 567.44 ft., and the grade is 0.55 percent., the maximum capacity being about 100 cu. ft. per second. This location was selected with the idea of draining still another area, farther south, in the event of a storm sewer being built on South Avenue. The cross-section of this sewer is the same as that of the Wood Street sewer. There is a gate manhole at the intersection with the levee, back of which no openings were placed.

Construction methods were the same as at the other sewers, but the trench was not completely backfilled because this portion of Front Street is within the limits of the spoil bank to be filled by the excavation from the river channel. The average cut was about 12 ft., and the material removed consisted mainly of rubbish from the city dump. This part of

FIG. 6. EQUIPMENT USED ON CONSTRUCTION OF BUCKEYE STREET SEWER, HAMILTON, OHIO.
Smith portable tilting ½-yd. concrete mixer; 3-ton Plymouth gasoline locomotive and four 1½-yd. side dump cars; portable electric derrick with ¾-yd. clamshell bucket.

Front Street has never been paved. Excavation began Aug. 13, 1919, and the sewer was completed Oct. 18, 1919. The quantities consisted of 2,750 cu. yds. of earth excavation, 310 cu. yds. of concrete, 1,700 lbs. of steel, and 680 lin. ft. of timber piles.

C. H. Eiffert, Division Engineer, is in charge of the local flood protection work at Hamilton, and the writer, as Assistant Division Engineer, has had direct charge of the sewer work. F. C. Williams served as superintendent from the beginning of the work to March 1, 1919, when he resigned and was succeeded by W. A. Roush.

PROPOSED SCHEDULE OF SALARIES FOR ENGINEERS IN COUNTY HIGHWAY SERVICE

The Committee of the American Association of Engineers on Salaries of Engineers in Public Service invites discussion of the proposed recommendations for salaries for engineers in county highway service before presenting it to the Association for final adoption.

As was the case with the positions listed for engineers in state highway service so it is with those here listed for county highway service, they are not to be interpreted as an outline for an organization for any particular county, but merely a list of positions with the corresponding salaries. The number of persons in a given position and the number of positions in a county office will depend upon the amount of highway work a given county is called upon to perform.

The Committee has recently completed its recommendations as to salaries for engineers in state highway service, which, after wide publicity and general discussion and having been approved by the American Road Builders' Association and the Association of State Highway Officials, has been submitted to the executive committee of the American Association of Engineers by whom it has been adopted. In studying the salaries for engineers in county highway service it will be useful to compare them with those recommended for engineers in state highway service published in the November 1919 issue of Municipal and County Engineering.

The Committee on Salaries of Engineers in Public Service consists of S. C. Hadden, Editor of "Municipal and County Engineering," J. H. Prior, Consulting Engineer on Public Utilities, Chicago; A. R. Hirst, State Highway Engineer, Wisconsin; F. H. Newell, President of the Association, and A. N. Johnson, Chairman, Consulting Highway Engineer of the Portland Cement Association.

Preliminary to drafting the recommendations for engineers in county highway service the following served as corresponding members of the Committee:

William A. Hansell, Supt. Public Works, Fulton Co., Atlanta, Ga.; W. A. Stinchcomb, County Engineer, Cuyahoga Co., Cleveland, Ohio; Leroy C. Smith, County Engineer-Manager, Wayne Co., Detroit, Mich.; George Diehl, Engineer, Erie Co., Buffalo, N. Y.; F. G. Tegtmeier, Engineer, Everett Co., Snohomish, Wash.; R. M. Morton, Engineer, Sacramento Co. Highway Comm., Sacramento, Calif.; George Quinlan, Co. Supt. Highways, Cook Co., Chicago, Ill.; E. A. White, Engineer, Pierce Co., Tacoma, Wash.

So that fullest discussion may be had and the largest

amount of information possible placed at the disposal of the Committee, each engineer receiving this is particularly requested to send his comments, whether of approval or disapproval, to the chairman of the committee. Address A. N. Johnson, Chairman, Committee on Salaries of Engineers in Public Service, American Association of Engineers, National Headquarters, 63 E. Adams St., Chicago.

The proposed schedule of salaries for engineers in county highway service follows:

Administrative Positions		
County Highway Engineer. In charge of all county highway and bridge construction and maintenance.	$5,000	$12,000
Engineers of Construction. Supervises all road construction and maintenance work, both contract and force account.	3,600	6,000
Engineer of Bridges. In charge of preparation of designs and specifications and construction of bridges.	3,600	6,000
Office Engineer. In charge of preparation of plans, specifications and estimates.	3,600	6,000
Senior Engineering Positions		
Assistant Engineers. Assigned to Office Engineer in preparation of plans and estimates computing and drafting, may act as chief draftsmen.	$2,400	$4,000
Assistant Engineers. In charge of tests and materials inspection.	2,400	4,000
Assistant Engineers. Assigned to Engineer of Construction or Engineer of Bridges acting as inspector of construction, also as chief of survey parties.	2,400	3,000
Junior Engineering Positions		
Draftsmen, Computors, Transitmen, Levelers	$1,800	$2,400
Rod and Chain Men, Tracers	1,200	1,500

REPAIRING BITUMINOUS MACADAM WITH COLD PATCHING MATERIAL IN PHILADELPHIA

By Wm. C. Bailey, Asst. Engineer, Bureau of Highways, City Hall, Philadelphia, Pa.

We had in Philadelphia a section of road on a through main traffic route which was resurfaced with a bituminous macadam wearing surface on an old water bound base about seven years ago, the surface of which was becoming very wavy and, in some spots, open. Our method of repairing this condition was as follows:

With spikes in the wheels of a road roller, enough holes were picked in the surface thoroughly to perforate it, having the holes about 4 ft. apart. All loose broken pieces were then swept off the road and the surface was thoroughly rolled. A cold mix, consisting of ¾ in. stone, sand and cold patching tar, (low carbon base) was then spread on the road in a sufficient quantity to make an even surface, in no place exceeding 2 in. in thickness, covered with about 20 lbs. of ½ in. trap rock chips per square yard and compacted with roller. This material was mixed at a central store yard in a mixer and hauled by auto truck to location where needed.

About two weeks after the road had been patched in the above manner, the entire section was given a surface treatment of Hot Oil, Asphalt Base, using about 1/5 gal. per square yard, and covered with 20 lbs. of ½ in. chips per square yard.

This road has been finished for about six months and is still in good condition, although being on a main road which is subjected to very heavy traffic between Philadelphia and Norristown, Reading and Bethlehem.

STANDARD SPECIFICATIONS FOR BRICK PAVEMENTS

By Maurice B. Greenough, Secretary, National Paving Brick Manufacturers' Association, Engineers Bldg., Cleveland Ohio

I Introduction

The paving brick industry through its Associations, has had the privilege since 1906 of placing in the hands of engineers and public officials specifications for brick pavement construction. The genuine demand that has always existed for this co-operation on the part of the industry (never more active than at present) has been met to the best of its ability. No effort has been spared to keep the specifications of the industry in accord with the best engineering practice.

Progress in highway transportation has been rapid in the last 14 years. New requirements have been laid upon pavements of all kinds. Various revisions have therefore been made in the National Paving Brick Manufacturers' Association specifications as they were needed. To meet local requirements most efficiently the several local subdivisions of the National Association have likewise issued specifications similarly revised as conditions have changed.

The first specifications issued by the Association provided for all types of brick pavements. They covered concrete, rolled stone and gravel bases, No. 2 paving brick bases and natural soil foundations. Fillers were sand, bituminous and cement grout. The bedding for the brick was sand. These specifications therefore offered a *wide range of choice* in meeting local conditions.

It must be recalled, however, that as far back as 1906 very much less attention than now was paid to subsoil drainage. The weakened condition of foundations saturated with water, overlaid by a pavement with sand and bituminous fillers (and from other causes that will be discussed later), produced a temporarily favorable attitude among engineers toward these types. For a number of years the requests for specifications covering these types of construction amounted practically to nothing, although they were then and afterward included in all

specifications published by the National Association. The great demand in nearly all parts of the country *east* of the Mississippi river was for the cement grout filled type of pavement laid on the sand cushion. Since there was so strong an expression of desire on the part of engineers for this type, it is but natural that the industry co-operated in its development.

The last previous revision of specifications made by the National Association followed the bringing out of the green concrete foundation type and its near-relative, the semi-monolithic type.

The time has come however, when a complete revision and co-ordination of all specifications of the industry is needed in order to align the industry with the progress of engineering thought in brick pavement design and construction. Also, to take advantage of the opportunity so greatly widened, created by greater experience and study in all matters of street and road improvement for public welfare. The study of paving economics has been intensified in the last few years as the importance of highways to the public has increased.

It has been proved conclusively that there is no universal type of brick pavement nor do engineers longer hold out expectation of one. They are convinced that flexibility of type is a distinct advantage of the public rather than a liability. *This is the keynote of specifications for brick pavements shortly to be presented to the public by the National Paving Brick Manufacturers' Association and its Member Associations.*

Fully to gage the value and significance of the new Standard and Alternate Specifications there is needed a brief review of brick pavement history. It should prove to be interesting and illuminating.

II History

By far the greater proportion of brick pavements laid up to 1895 were filled in the joints with sand or bituminous material. For many years they were laid on natural foundations. Artificial bases had their inception in the belief that thus imperfectly drained or consolidated subgrades might be bridged over and settlements in weak spots prevented. The cushion or bedding beneath the brick primarily was intended to compensate for unevenness in the surface of the base. Sand and bituminous fillers continued to be used after the construction of artificial bases became general.

With fillers of these kinds, chief reliance for the durability of the pavement as a whole was placed in the wearing qualities of the individual service-unit. That confidence was not misplaced is evidenced by the very large numbers of brick pavements more than 25 years old that are still doing duty with and without artificial bases. Parenthetically it may be said that those pavements which were originally sand-filled are among the best of these. At the time of which we are speaking there had not been developed a bituminous filler that could meet the much-specified requirement that "it shall not flow in hot weather nor become brittle in cold weather." The result was that as soon as the filler had left the joints, the edges of the brick cobbled. Pavements then became noisy, naturally enough, when traversed by iron tired vehicles. Nor could the open joints be justified in view of the increasing demand for clean streets since open joints collected so much pavement refuse.

The development of cement-grout-filled brick pavements grew out of these conditions. The hard filler it was thought would protect the edges of the brick. Cobbling under traffic would be prevented and at the same time a surface of 100% sanitary value provided. Moreover, it was believed that the firm bonding of each brick to its neighbor would furnish a monolithic wearing surface reflecting *all the inherent service-value of the individual brick composing it.* Just as the sand cushion had been used with sand and bituminous fillers it was continued in use with the cement grout filler.

Many millions of square yards of brick pavements on the sand cushion were built in the period from 1895 to 1915. This type came to be regarded as the all but universal kind of brick pavement to be built in the East, the South and throughout Ohio, Indiana and Illinois. This district was each year a larger user of brick for paving. Engineers sincerely believed that the cement grout filled brick pavement was the solution of most of their problems.

Furthermore, it is apparent that this opinon could not have been wholly without a foundation of fact. The type could not have been utterly unjustified. Had it been, brick could not have gained the favor it has in the public mind if its service behavior had been altogether lacking. Nor could the paving brick industry have had the strong and vigorous growth that came to it during that period.

It became increasingly apparent, however, in observing this type in service as built under average working conditions, that the sand cushion was a tricky and dangerous element of the structure. Uniform compression was the exception rather than the rule. In all too many cases patches of the surface have been broken down. The brick have given every appearance of being crushed under traffic. In fact, in the minds of many, the cause was attributed to defective brick. It was soon discovered, however, that the real cause was in an imperfectly compacted sand cushion. The sand would be forced into the joints from below when the surface was rolled. The filler could enter the joint (in many cases) only a fraction of an inch. A force was therefore exerted upon a fraction of the face of the brick, and the worst situated fraction at that, which snapped off the entire tops of the brick.

This type, possible to be built satisfactorily with the use of care and thorough supervision, was finally found inadvisable for further use. The hazard was too great. It was satisfactory neither to the public nor to engineers who had sponsered it nor to the paving brick industry.

The solution seemed to be found in the development in 1914 of the green concrete foundation type and the semi-monolithic type of brick pavement. If you will consult the literature of the period from 1914 to 1916 you will find constantly reiterated belief that the principal merit of the two types lay in the elimination of the hazard of the sand cushion. That belief has been justified in the facts.

It has also been proved, as was predicted at that time, that while longitudinal cracking common to the sand cushion type in frost latitudes, while not altogether eliminated, has been reduced. Entirely to do away with these cracks in slab pavements is a "consummation devoutly to be desired," and must await a more perfect knowledge of soil and drainage conditions and a better understanding

of internal stress and strains in monolithic pavement structures. Even with a development of this phase of pavement construction many times more thorough than at present, it still must be proved that subgrade drainage is a cure-all rather than an aid for the prevention of slab pavement cracking or concrete base cracking.

It was further believed of the monolithic and semi-monolithic types that the unit structure created by the intimate union of base and wearing surface would bring about increased stability, hand in hand with economy in design, as compared with the sand cushion type. For a variety of reasons that will be discussed later it is already apparent that possible economy in design has not been taken advantage of by engineers to the extent that it is available. In fact, in some localities the opposite is true. But more of that later.

You will recall at this point that so far the discussion has been confined to the section of the country East of the Mississippi river. What of the West? What of the portion of the country that undertook its paving improvements outside the largest centers of population, considerably later than East of the river?

In its early brick pavements the West somewhat naturally followed Eastern precedent and used the bituminous fillers or sand to a large extent. Being in the field of asphaltic oil production it naturally turned to asphalt filler as the principal one. On account of its being a native product there was every reason for developing it to the highest possible point of efficiency. For many years the progress attained did not justify too optimistic hopes that fillers would be produced superior to those that have already been described as to behavior. But there is this marked difference in the course which paving practice followed. Where the East turned from bituminous to cement grout filler, the West persevered in its endeavor to improve its asphaltic filler. And finally success came.

Fillers produced showed increasing stability under high temperatures and less brittleness under low. And about 1912 it could definitely be stated that a filler had been found that would not flow in hot weather nor chip out of the joints from brittleness in cold weather. It would remain in the joints with apparently no loss of vitality that could be discovered over a period of years. It did afford the desired protection to the edges of the brick. It met the requirements for quietness and sanitation. Minor readjustments of the surface of the pavement are not followed by harmful disturbances as is true with hard filler.

This filler has been improved still more since 1912 and in its improved form has been adopted in the asphalt filler specifications of the National Paving Brick Manufacturers Association and also by the Asphalt Association. We shall discuss it at greater length a little later. We are getting to the close of our review, which would not be complete, however, without some reference to the changes undergone by the brick themselves in the period from 1895 to that we are discussing.

Prior to 1895 nearly all brick laid measured 2¼x4x8 to 9 ins. They were plain wire-cut and unrepressed. They were thoroughly well vitrified brick; so much so that they were sometimes somewhat irregular in shape. But they did possess beyond question unequaled wearing qualities. They were very tough and very hard. It was at about this time that agitation began among engineers for a brick of more perfect shape. The response of the paving brick industry was the brick of the so-called block size—3½x4x8½ ins. The 3½-in. width was selected on account of certain alleged convenience in affording the grip for the calks on horses shoes. It is a well established fact that no scientific principle, either from the manufacturers' standpoint or the engineers', led to the adoption of the 3½x4x8½-in. size.

Coincidentally with the making of the block size came the addition of projections or lugs for spacing. The plain wire-cut brick had done their own spacing. With the extreme regularity that was expected with repressed brick the lugs were deemed neecssary. With perhaps equal weight the argument for foothold for animals was advanced as an additional reason. The fact that cement grout filler had come into use did not have a great deal of influence as far as lugs were concerned until engineers began to use the coarse grades of sand in the grout. It is also true the rounded edge of repressed brick assisted rather than otherwise, the entrance of sand cushion into the joints from below.

Older engineers who were laying brick at this time will confirm the fact that cement grout filler was used with the plain wire-cut brick without difficulty. There are too many of these old streets still in use in this very section of the country to speak other than in the affirmative on this point.

Once the block size of brick began to be made by practically all manufacturers, there was practically no change in the size or shape of brick until in 1910 there was developed west of the river the wire-cut brick 3x4x8½ ins. in size, having two instead of four lugs formed by the die instead of being repressed.

Also, there were produced East of the river, contemporaneously, wire-cut-lug brick that aimed to recognize the demand for the advantages of wire-cut as against repressed brick. In size no change was made from that of the repressed brick. Edges of this and the wire-cut brick West of the river were square, whereas, repressed brick were round-edged.

Wire-cut-lug brick and the vertical fiber brick (both trade names) had lugs. In the first case they have been retained: in the latter case engineers by 1917 had become convinced that the lugs were superfluous. This point of view is spreading rapidly among engineers and the public and to meet the new conditions the National Paving Brick Manufacturers Association has adopted the 3x4x8½ brick as its standard product.

III Modern Conditions

Earlier in this paper we discussed the fact that no longer can it be said that there is a universal type of brick or other pavement. Let us analyse this statement and see if it is tenable. Let us make comparisons with other lines of engineering work.

Do we use standard footings for all columns in high building construction? Do we use standard designs for every bridge pier; for all dams; for each retaining wall?

The answer of course is "no?" Yet these are comparable departments of engineering. Each of these structures is called upon to support loads and each rests upon whatever soil foundation is available in each case. We must bear in mind also that each of these is a localized

structure with a minimum expectation of variation in subsoil beneath it. Yet we very well know that subsoil and also surface soils vary noticeably within short distances.

In spite of the precedent for individual designing thus established for structures resting upon the earth, it has been ignored to a great extent in road construction. Engineers have not insisted with that energy with which sound principles should be supported, that subsoil and surface drainage should be made as perfect as possible.

Drainage has been neglected to the point of being ignored. Coupled with the known fact that soils vary within short distances and the saturated subsoils afford little if any bearing value for the pavement structure, we have blindly gone ahead and required the construction of "Standard" types of pavement without regard to these conditions. It is not unusual that the same kind and depth of base will be specified for a road 12 miles long. If the section is adequate for the worst condition then it is extravagantly designed for every other condition.

Extravagance is not compatible with sound engineering. Because in one locality a brick pavement, for example, has been built on a 4 in. concrete base is not justification universally for that depth. Conversely, it does not follow that because a 6 in. base seems to be needed in one place that the same depth is required a mile away.

The time is coming, and it is not far distant, when a single stretch of pavement will be designed in 100 ft. sections. In a given contract for a single road there may be concrete base, rolled stone, gravel or slag base; each one may be anywhere from 4 ins. upward in depth. And if we carry the thought to its logical conclusion there may be portions requiring no artificial base.

Individually designed roads are a necessity. The use of blanket types is wasteful. It ignores the fundamental principles upon which the character of the profession's public service is founded. It cannot endure.

Clearly the practice of standard sections of pavement is the outgrowth of ignorance of the fundamental laws of pavement design. Not knowing the facts, we design blindly. If all the money that has been wasted in standard section could have been spent in research to discover these laws we should long since have been on the high-road to real economy in pavement construction and use. As it is we are aimed in the opposite direction.

The very ignorance in which we work is responsible also for ill-considered pronouncements of theory that have no foundation in proved facts. It is nothing new to recall that the virtue of a conclusion rests upon the initial premise. It is quite possible to make assumptions that will yield any desired result in subsequent analysis. The verity of the result lies not in the conclusion, but in the underlying facts. Fundamental laws of mechanics, unfortunately, do not disclose error when assumptions are made that can yield but one conclusion, and that one predetermined.

No better illustration of the fact can be cited than the alleged beam theory of pavements. It is very well known among students of mechanics—presumably a proper synonym for engineers—that the simple beam theory applies to an unsupported span on fixed supports at each end—the ends of the beam being free to move. If the argument is advanced, as it frequently is, that a comparable condition exists in the bridging of a trench, then the theory as applied to pavement falls to the ground because the ends are not free to move.

As nearly correct a description of a slab pavement as we can now write is this: It is a continuous slab resting upon a continuous support of varying elasticity, to be designed to carry moving loads. As yet we do not have a proved analysis of such a structure. The nearest approach to it will be found in the analysis of rail stresses, and as far as this work has proceeded it is based upon results secured by the use of an extensometer under actual service conditions.

It will also be recalled that the simple beam theory is based upon positive bending moments. There are no negative moments in a simple beam. The moment beam or slab continuity is introduced, however, you have set up a consideration of negative moments. Under moving loads a negative moment moves in advance and in rear of the load, and is effective in the vicinity of the support. Witness the analysis of continuous beams on fixed supports. Just what happens on elastic supports is yet to be shown.

Admittedly this discussion is theoretical; admittedly, also, sufficient points have been raised to discredit the simple beam theory as applied to slab pavements. But fortunately we have recent data presented by the Office of Public Roads, derived from the measurement of the effect of motor trucks upon pavement surfaces, to show that the principal force of traffic to be met is impact and not bending. Surely engineers will not longer, in justice to the standards of the profession, continue in the path of the beam theory. Its fallacy is too evident.

What, then, can we do while awaiting the production of scientifically determined data that can be used with the backing of proof? The answer to that question is clear. We should return to first principles. We should place ourselves upon the safe ground of minimum hazard.

In the end that means the abandonment of cement grout filler as far as brick pavements are concerned. It means that in many cases concrete bases will be supplanted by another type—the rolled base. It means the passing of standard cross-sections of pavements of all types. And these things mean laying the foundation of real economical pavement design.

The coming of a saner period of pavement design is evident. Already the reaction against slab pavements is setting in and the rolled base is in the ascendency. And we should not forget that there is more than one type of rolled base. Some are water-bound, some tar-bound, some bound with dry screenings. Local stone secured by the roadside is adequate. The keynote of this type, as it should be of all types of base, is sufficient serviceability at minimum cost.

Durable wearing surfaces on bases meeting this criterion mean economical pavements.

IV. Specifications

The forthcoming specifications of the National Paving Brick Manufacturers' Association will recognize the principles that have been discussed in this paper. The specifications will be specifications of details. There will be a concrete, rolled stone, gravel and slag base bound with screenings and with tar. There will be asphalt filler and alternates of sand, cement grout, and combined tar and asphalt fillers. The sand cushion will be specified to accompany bituminous and sand filler, the cement-sand bed

or the green concrete base where cement grout filler is used. The specifications will be published in sections. By proper selection a type of brick pavement can be specified that will meet local conditions with economy.

In response to a well-defined and growing demand on the part of engineers and the public for stabilizing the character of its product, the National Paving Brick Manufacturers' Association has adopted the 3x4x8½-in. square-edged brick without lugs as its standard. Already the demand has brought about the exclusive manufacture of this brick by a large portion of the industry, and as rapidly as the market for this brick requires it, production will be increased. If it grows at the rate now evident, it will be but a short time before variety in brick types will be a thing of the past. The sooner this occurs, so much the sooner will engineering progress of real worth be made. The element of the wearing surface will become stabilized, permitting such variation in bases as is needed the best to meet a given condition.

Summary

To sum up the base of brick pavements at the beginning of 1920, we may state these points as clearly defined:

1. The value of thorough subsoil drainage is becoming realized.
2. The use of a variety of kinds of bases to meet different subsoil, traffic and economic conditions is established firmly.
3. The tendency of design is away from the slab types of brick pavements and toward the types that depend upon the high quality of the individual unit as against the monolithic surface.
4. The use of cement grout filler is on the wane.
5. The coming year will see the widespread adoption of the standard brick in localities now laying numerous varieties of lug brick.

Acknowledgment

The foregoing paper by Mr. Greenough was presented before the Illinois Society of Engineers at the 1920 annual convention.

IMPROVING SEWAGE PLANT OPERATION

By C. H. Currie, Civil and Sanitary Engineer, Webster City, Iowa

Improving poor operation of sewage treatment plants in average and small communities is probably the most vital problem confronting Public Health Officials and Sanitary Engineers. This is true in the State of Iowa and in the neighboring states and is undoubtedly true in other places. But the writer, being more familiar with sewage treatment plants in the State of Iowa, will confine this article to that state.

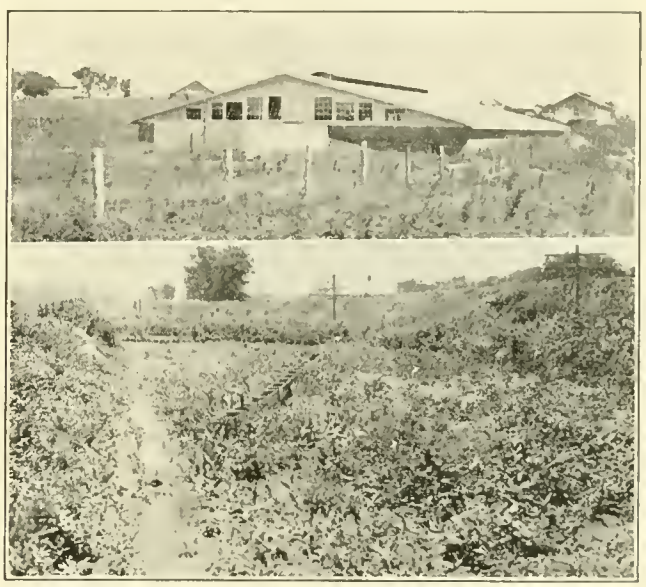
Why Some Sewage Plants are Neglected

Sewage treatment plants are comparatively new and, especially in small places, they almost universally lack appreciation and care, which might naturally be expected. Fundamentally, the ideal way of insuring proper operation of sewage treatment plants and the consequent safety of the effluent, would be to have all in a community understand and appreciate the importance of this subject, as well as do our State Boards of Health. The engineers, as a class, may oftentimes be rightly accused of criminal modesty in not securing all possible publicity of an educational nature for such a municipal project.

Turning Public Prejudice Into Public Pride

In the writer's opinion, one of the first things to be done in turning public prejudice into public pride on a subject of this kind is to improve the general neighborhood and surroundings of such a plant. Second, make the structures more pleasing in appearance. Third, maintain the plant and grounds surrounding it so as to make it attractive, instead of permitting it to assume the appearance of a dumping ground or similar eyesore.

Many communities are failing to protect themselves properly and their neighbors by not installing sewage treatment plants because of the impressions they have formed from viewing plants in neighboring towns which have fallen into a state of poor repair and consequent ill repute. In many towns and cities in Iowa under 3,000 population, such a deporable condition does exist, as is



VIEWS OF TWO SEWAGE TREATMENT PLANTS IN IOWA.

Upper View: Housed filters at New Hampton in foreground. Housed Imhoff tanks at rear. Nearest dwelling house about 500 feet from plant, but houses will eventually adjoin plat where plant is located.

Lower View: Neglected sewage filter at West Liberty. This plant is remote from residences and its remote location leads to its neglect.

evidenced by the results of examinations by the State Board of Health. Unfortunately the State Board of Health of Iowa does not have sufficient funds appropriated for this purpose, so that they can make the necessary visits to every community having treatment plants and keep the officials of that community alive to the necessity of proper operation, as this would be of material assistance in improving the conditions existing at present.

Influence of Location on Care of Plant

Many of the former treatment plants were constructed, some through necessity and some through intent, in inaccessible places and near disreputable surroundings, such as dumping grounds, slaughter-houses, etc. In such surroundings one can scarcely expect that much civic pride will be expended upon proper care and operation of sewage treatment plants, and it will be pretty hard through

any method of publicity to overcome the prejudice of a community having such a condition existing. The easiest method would be to clean up the neighborhood, the surroundings, and the plant itself, make it accessible and keep it in good condition.

Value of Superstructures of Good Appearance

Since 1912 more sewage treatment tanks in the State of Iowa have been constructed with superstructures of

VIEWS OF THE SEWAGE TREATMENT PLANT AT MASON CITY, IOWA.

Upper View: Housed Imhoff tanks, dwelling houses are less than a block away. Lower View: Covered trickling filters.

pleasing external appearance, more care has been given in cleaning up and leveling of the grounds surrounding the tank and the filters, and in some instances some attempt has been made at modest landscaping. While possibly a few such plants have been neglected, a comparison of the relative efficiencies of such plants, where well located and kept up with plants not so fortunately located and constructed, is an indisputable argument in favor of the former.

Two Examples

The writer was very strongly impressed with this the past summer in visiting two towns of about 1,000 population each, within 30 miles of each other, one of which had built its treatment plant eight or ten years ago, the other one about three years ago. One of the officials reluctantly accompanied him to look over the first treatment plant and the conditions found were as follows: The tank was of the old type with the slab cover at ground level, and the citizens, owning the ground surrounding this and thinking of no other good location, had for some few years past been using it as a public dumping ground, so that refuse and garbage had piled up until it covered a part of the settling tank. The filter beds were faintly defined by the relative height of weeds and naturally the effluent from this tank was little better than raw sewage. Upon inquiry, the official advised the writer that they had received letters from the State Board of Health urging them to look after their sewage treatment plant, but found it hard to get a man to look after it, that the fellow who did know how had left town and no one seemed to kick on the effluent, except a short time in the summer, so that they did not feel like spending much money on it. He was of the opinion that the tank was no good and that they might need a new one. The writer was unable to secure a full set of plans, but, from what he saw, is of the opinion that the plant was well designed and if proper care had been given, it would be affording a safe effluent today.

The other town visited had a well located plant, easily accessible from public highways, with a pleasing superstructure. In company with one of the officials we went over this plant very carefully, and the writer was particularly impressed with the attitude of this official, and other citizens whom he visited with later, who instead of being ashamed of such a plant, all seemed somewhat familiar with the general principles involved in the purification of sewage, and considered this plant one of their chief assets.

One banker remarked that he had taken visitors there, which was one place he had never imagined could be a point of interest and pride, before seeing their plant. Such an attitude almost guarantees this town future successful operation, as they have employed an engineer to visit them and advise their operator whenever necessary.

The few pictures of different plants, shown herewith, while not taken with this subject in mind, will serve to illustrate the points covered.

Comparatively few plant operators have ever seen their tanks empty and probably do not have a mental picture of the entire structure and are doing their work or part of it in a "rule of thumb manner." It is suggested that a well-framed set of instructions, simple and shortly worded, indicating the things most vital in the care of the different units of a treatment plant, together with isometric drawings showing the construction of the entire plant and the important things requiring attention will prove of great aid to the operator and insure more intelligent care with consequent better results.

FUNDAMENTAL CONSIDERATIONS AFFECTING CONCRETE PAVEMENT DESIGN

By S. T. Morse, City Engineer, Carlinville, Ill.

The recent large expansion in the use of concrete for constructing the modern highway renders it highly important that paving engineers thoroughly understand the structural laws and natural conditions affecting the proper design of such roadways. It is to be conceded that the past status of the science has not, as yet, provided generally recognized rules for the guidance of engineers in designing the thickness and form of their pavements. Each engineer, usually, has provided an edge and central thickness based on his particular experience or judgment, and thus the spectacle is presented of some highway departments using an edge thickness of 6 ins., others of 7 or 8 ins., while some use a central thickness of 7 ins. and others up to 10 ins. It therefore seems advisable that generally accepted standards be determined and adopted; for, at the present price of 30 cts. per inch of thickness per square yard, the paving engineer, who can without structural failure, by his application of correct methods of design, reduce the specified thickness of a mile of concrete pavement 1 in. has earned his salary for one year. Contrariwise, if through a lack of such knowledge, and a

desire to construct cheaply, the pavement section is constructed too light, the public has lost much more in maintenance costs and early reconstruction. Therefore with more than $600,000,000 to be expended for roadways in the immediate future, the correct design of concrete pavements has become a question which should at once be placed on a recognized and correct scientific basis.

Design of Form

In developing the true method of designing the slab of a concrete pavement, the active external forces must be carefully determined, and the forces of resistance be made equal thereto.

The fundamental considerations which mainly affect the rational determination of the thickness and form of a concrete pavement are as follows:

First—The nature of the foundation, whether it be of muck, clay or sand, whether in a dry, moist, saturated, or frozen condition.

Second—The nature, speed, and weight of the moving loads which are likely to pass over the pavement, which includes the nature of the tires and springs.

Third—The strength of the concrete to be used, which includes a knowledge of the mixture, the character of aggregate, the amount of water used, time of mixing, and the age at time of first major test.

Fourth—The width of the pavement under consideration.

In the light of the present knowledge of the subject, the effect of each of the first three factors may now be determined within rather narrow limits, and the fourth factor is always a known quantity. A brief discussion of the four conditions and their probable effect on the design will now be given:

The Foundation

First—On the nature of the foundation, whether of clay or of sand, whether wet or dry depends the amount of vertical motion transmitted to the edges of the pavement by the freezing of the earth beneath the edges. For more complete details of the action of this factor see articles by the writer on concrete pavement construction in Eng. & Cont'g. of July 9, 1913, and Feb. 7, 1917. It has been definitely shown by Mr. J. W. Lowell, see Eng. & Cont'g. Nov. 6, 1918, that "The vertical movement or heaving naturally is greatest at the sides where moisture is a maximum and decreases toward the center." It was further shown that the vertical motion of a clay subgrade may equal 7/16 in., and was found to be much less on a sandy subgrade.

Concrete slabs deflect with the movements of the sub-grade if their stiffness is not sufficient to carry their weight, and, if the deflection becomes great enough, a crack develops along the line of greatest stress, a structural failure is the result.

The writer has observed the upheaval of pavement edges due to frost, to be as much as ¾ in. The point or line of application of the summation of these upward or reacting forces becomes the point or line of support for each side of the slab. These lines of support are located at some distance from the edges toward the center of the pavement, and the distance varies with conditions of the weather, and the wetness and character of the subsoil. The distance of the line of support from the center of the slab, being a variable, may be denoted by x, a factor of the span or width of pavement. No definite determination of the extreme location of these lines of support has, as yet, been made, but the maximum stress in a slab is obtained when these lines of reaction approach nearest the edges of the pavement; through a period of 7 years of close observation of this feature, the writer is convinced that these lines of support at times approach very near to the edge of the pavement where the slab is stiff and strong enough to sustain itself, and in this discussion x will be given a maximum value of 0.95 which is considered safe and representative of the facts.

Weight and Speed of Moving Loads

Second—The weight and speed of moving loads which the pavement is expected to support has an effect in stressing the slab second in amount only to that caused by the dead weight of the slab; in fact, it may be shown by the equation hereinafter proposed that a wheel load of 5 tons multiplied by a shock factor of 4 may cause as much stress in slabs 15 ft. in width as does the dead load under maximum conditions, and that the moving load becomes the major factor in more narrow slabs.

It has been theoretically demonstrated by Mr. J. W. Pearl, see Eng. & Cont'g. Feb. 11, 1914, that a concentrated load on a concrete slab is distributed over a circular area which has for its diameter, approximately, the width of the slab, within certain limits, and that the bending moment

$$M = \frac{Pr}{4},$$

equating to the resisting moment

$$\frac{Pr}{4} = \frac{2\,\Pi r f t^2}{6},$$

from which equation No. 1 is

$$t^2 = \frac{P}{4f},$$

where t is the thickness of the slab, P the load, and f the unit stress.

For further discussion of the effect of static loads on slabs, see article by Mr. E. B. McCormick before the 11th Annual Convention of the American Concrete Institute, Feb. 9, 1915, and Bulletin No. 28 of the Ohio State Highway Department.

In equation No. 1, there is no provision made for including the effect of shock which arises from moving loads. The amount of shock depends on the weight, the speed, roughness of the road surface, kind of tires, and the springs, and in all previous efforts to evolve a correct equation expressing thickness the writer, and no doubt others, have been hindered by this unknown shock quantity which may be represented by the symbol y, and equation No. 1 becomes

$$t^2 = \frac{yP}{4f}, \quad (2).$$

The U. S. Bureau of Public Roads has recently been making these much needed impact experiments, and while a full report is very difficult, if not impossible to obtain, the important results have been reported by Mr. A. T. Goldbeck, its Testing Engineer, in a paper abstracted in Eng. & Cont'g. Dec. 3, 1919. Quoting from this paper,

"The indications are that when a wheel load of 8,500 lbs. is at rest on an 8-in. concrete slab laid on a rather wet subgrade the fibre stress in tension is only about 34 lbs. per square inch directly over the load." Substituting the above known quantities in equation No. 1 and solving for the real value of f in said equation, we find that

$$8^2 = \frac{8{,}500}{z34}, \text{ or } z = 3.9$$

which is a very practical verification of the theoretical value 4, and with this verified value of the factor of f further investigation may proceed with confidence.

In his paper Mr. Goldbeck stated that "The highest pressure thus far measured being in the neighborhood of 42,000 lbs. when the weight on the rear wheel causing this pressure was only 7,750 lbs. The unsprung weight on one rear wheel of this truck was 1,837 lbs." This pressure was very exceptional, and the experiments show, in general, that the maximum pressure caused by impact was about four times the static weight of the wheel load, from which a fair value of the factor y may be placed at 4. Using the highest pressure found, viz. 42,000 lbs., under the conditions named the unit stress developed could not exceed about 165 lbs. per square inch, from which it must be conceded that the moving load is but one of the rather minor factors affecting the design of concrete pavements.

Strength of the Concrete

Third—The third fundamental affecting road design has to do with the resisting moment of the slab itself. The resisting strength of a concrete slab is controlled, mainly, by the relative amount of cement used, the grading and quality of the aggregate, the amount of water, the time of mixing, and the age of the slab at the time of stressing. A short consideration in detail of these factors will be given following the discussion of the form design.

Quoting again from Mr. Goldbeck's recent paper "The modulus of rupture of the ordinary concrete road mixture is well over 400 lbs. per square inch, and possibly as much as 600 lbs. per square inch." These values of f are substantiated by tests of Prof. A. N. Talbot, and by tables of Taylor and Thompson; so that with a concrete mixture of 1-1½-3, a conservative value for f may be assigned at 400 lbs. Also, with a mixture of 1-1-2, according to all available tests, it is quite as conservative to assign a value of 500 lbs., to f, the modulus of rupture, which leads at once to the very interesting conclusion that a concrete pavement of equal strength may be designed as cheaply with a mixture of 1-1-2 as one of 1-1½-3, and, according to the recent tests, of Prof. D. A. Abrams, the abrasive resistance increases as the strength of concrete increases which indicates that at least 30 per cent. more wear may be expected from the richer mix at the same cost. This idea is injected for future consideration, and it is hoped, will not cloud the issue directly in hand.

Width of Pavement

Fourth—The width of the pavement has a most important bearing on the road design in that it is properly the span of the beam considered, and by the laws of flexure enters the problem as its square; the equation for the moment of a simple beam being

$$M = \frac{w(x12L)^2}{8},$$

in which w equals the weight per square unit $= \frac{t}{12}$, and L equals the width of the pavement in feet. Equating to the resisting moment,

$$\frac{12t\,(xL)^2}{8} = \frac{fbt^2}{6}, \text{ from which } t^2 = \frac{9t(xL)^2}{f}, \quad (3).$$

Equation (3) indicates that the thickness of concrete pavements must be increased as the square of the width increases, nearly. Since the present tendency is to increase the width of roadways to a minimum of at least 20 ft. for all double traffic roads, it is very evident that accurate knowledge of the design necessary to fulfill the structural requirements should be at once at hand to the end that the $600,000,000 available for immediate construction may be expended without undue structural failure, and with the full assurance that there is not material waste by uneconomical design of form and thickness. Quoting Mr. Goldbeck "In the face of such an enormous program it behooves us to build wisely lest we be extravagant either by too much or too little initial expenditure for our various road systems." We must not be satisfied with a constant cross-section irrespective of the fundamentals affecting road design.

Having considered in the above discussion the fundamental conditions which affect the design of concrete road slabs, a fundamental formula for the rational design of concrete slabs placed on shallow, unstable foundations may be derived.

Since the bending moments are proportional to the square of the thickness of the slabs equations (2) and (3) may be combined and

$$t^2 = \frac{9t(xL)^2}{f} + \frac{yP}{4f}, \quad (4).$$

from which the general formula is obtained,

$$t = \frac{4.5(xL)^2}{f} + \sqrt{\frac{yP}{4f} + \frac{20(xL)^4}{f^2}}, \quad (5)$$

Ascribing to x the value 0.95, and to y the value 4 as determined in the above discussion,

$$t = \frac{4L^2}{f} + \sqrt{\frac{P}{f} + \frac{16L^4}{f^2}}, \quad (6)$$

which, using f = 400 with a concrete mixture of 1-1½-3, becomes

$$t = \frac{L^2}{100} + \sqrt{\frac{P}{400} + \frac{L^4}{10{,}000}}, \quad (7)$$

and using f = 500 with a concrete mixture of 1-1-2, equation (5) becomes

$$t = \frac{4L^2}{500} + \sqrt{\frac{P}{500} + \frac{16L^4}{250{,}000}}, \quad (8)$$

The writer presents general equation No. 5 to the paving world for guidance in the rational design of

the central thickness of concrete pavement slabs with entire confidence that it will be found correct in form, convenient to use, and that it will provide safe weights within the assumed conditions of service. The thicknesses given will prove to be slightly excessive for pavements built on sandy foundations which will give opportunity for the exercise of good judgment, guided by the formula.

As an illustration of the value and applicability of a rational, recognized method of designing slabs, consider the concrete road being built from Mt. Clemens to Detroit which is reported to be 8 miles in length, 24 ft. in width and 10 ins. in thickness, applying equation (4), it is found that, with a clay subgrade, the unit stress as planned may run as high as 560 lbs. per square inch which is too high for most concretes, and unless all of the foundation is quite sandy, a number of structural longitudinal failures are likely to occur which will require considerable maintenance expense. Either the central thickness should be increased to 12 ins., or better, two parallel, adjoining slabs 12 ft. in width may be constructed with a uniform thickness of 7 ins., which on this road, estimating the cost at 30 cts. per inch of thickness per square yard, will save in first cost $12,000 per mile, or a total of $96,000 on the job. If 10 per cent. of the amount saved be placed at 5 per cent. interest it will return $60 per year per mile as a maintenance fund which is much more than well built concrete roads have been costing to maintain. There are many extravagant examples of this character. It seems important that a recognized system of design should be generally adopted. The writer has eliminated the longitudinal crack from pavements of his construction.

Design of Mixtures

The quality of materials, their proportions, the grading of the aggregate, the amount of water, the time of mixing determine to a large extent the strength and abrasive resistance of the road.

Cement—Considerable difference still is found in the fineness, strength and soundness of the various brands of cement. The quality should meet the requirements of the A. S. T. M. standards. The writer requires a tensile strength of 700 lbs. per square inch 28 days after mixing. The care and expense incurred in procuring the best of other materials and proper workmanship must not be discounted by the use of poor cement.

According to all available tests, there is a very marked increase in the strength and durability of a concrete having a mixture of 1-1-2, over one having a mixture of 1-1½-3, amounting, approximately to 40 per cent. additional strength with about 37 per cent. more cement. The modulus of rupture and the abrasive resistance appear to be likewise increased. With an increased knowledge of the design of pavements, the writer has the temerity to suggest that within the near future, the first-class roads will be constructed with a mix of 1-1-2, and at no greater cost per square yard.

Aggregate—The grading of the aggregate should be made the subject of much consideration. The fund of information concerning the correct grading has, recently, been much increased by the many tests made by Prof. D. A. Abrams of the Lewis Institute, Chicago, who has clearly defined and uses what he terms the "Fineness Modulus" as the standard guide for determining the correct grading of the aggregate. The writer finds this method easily workable, and definite in its results. In preparing specifications, it seems advisable to provide a definite proportion, such as 1-2-3 with the added clause, "Except that when the 'Fineness Modulus' as defined by Prof. D. A. Abrams in Bulletin No. 1 of the Structural Materials Research Laboratory, Lewis Institute, shall be less than 5.5 then the above specified two parts of sand shall be reduced in quantity, and when the said 'Fineness Modulus' shall exceed 6.0, then the amount of sand used shall be increased in excess of the specified two parts." Such a specification provides a definite basis for making estimates of cost and quantities, and a definite system for properly grading the aggregate; it requires that the Engineer in charge shall have and use frequently a set of standard sieves, which each paving engineer should possess.

Water—By his many tests, Prof. Abrams has also proved the first importance of holding the amount of water used, relatively to the amount of cement used, at the lowest possible point which will provide a workable mixture. He has shown that by decreasing the water used in mixing from an amount of 100 per cent. to an amount of 85 per cent. of the quantity of cement used, the strength of the resulting concrete is increased as much as 25 per cent. Hence, if the modulus of rupture "Of the ordinary concrete road mixture," as stated by Mr. Goldbeck, is as much as 400 lbs., then the modulus of rupture of a concrete mixed with the correct amount of water would be at least 25 per cent. more or 500 lbs., and applying equation (6) for required thickness for a road 16 ft. in width, we find, using the dryer mixture, that the required thickness is 7.05 ins. as against 8.17 ins. for the ordinary wet mix, or a real saving of 1.12 ins. in thickness of concrete, which at 30 cts. per inch per square yard will save $3,150 per mile of road 16 ft. wide. It is to be conceded that the dry mixture requires more labor and time in construction, but the above amount of saving will pay the contractor for considerable time and trouble, and also provide for considerable added inspection, moreover ways and methods will speedily be found to reduce the added cost of the dry mix to a negligible quantity. The above determination is but another illustration of the advantage of having for use a formula and recognized system of design for concrete roads.

Such tests as those made at the Lewis Institute are welcomed by all engineers, and certainly great credit is due Prof. Abrams.

The above stated methods of design will provide a concrete pavement with sufficient central thickness and strength to prevent the central longitudinal cracking, so frequently observed, and will also assist designers in

TABLE I—SHOWING THE REQUIRED THICKNESS AND RELATIVE COST PER SQUARE YARD OF WIDE AND NARROW PAVEMENTS. P = 10,000 LBS.

Concrete Mixture Cement, Sand, Stone	Estimated Cost per Inch per Sq. Yd. cents	Road Width 10 Ft. Thickness Required t (ins.)	Road Width 10 Ft. Cost per Sq. Yd.	Road Width 12 Ft. Thickness Required t (ins.)	Road Width 12 Ft. Cost per Sq. Yd.	Road Width 16 Ft. Thickness Required t (ins.)	Road Width 16 Ft. Cost per Sq. Yd.	Road Width 20 Ft. Thickness Required t (ins.)	Road Width 20 Ft. Cost per Sq. Yd.
1-1½-3	30	6.1	$1.83	6.64	$1.99	8.17	$2.45	10.4	$3.12
1-1-2	35	5.34	$1.86	5.78	$2.02	7.05	$2.47	8.22	$2.88

avoiding extravagant and excessive central thickness toward which the tendency now is.

There yet remain for discussion and solution, the questions of edge thickness, and the elimination of transverse cracks. It may ultimately be determined that the forces which produce the majority of transverse cracks are also the forces which will govern the required thickness of the slab at its edges. The writer is investigating this phase of the subject in particular, and has made at least one unexpected and interesting discovery. Experiments, looking toward the entire elimination of transverse cracks, also, are in progress, but results will not be available for another season.

It will be a cause for much satisfaction among paving engineers, certainly, if it may soon prove to be that concrete pavement slabs may be economically constructed with full assurance that they will not structurally fail.

THE PROPER WIDTH OF A PERMANENTLY PAVED HIGHWAY

By Monroe L. Patzig, Consulting Engineer, 418 Kraft Bldg., Des Moines, Iowa

To me durable highways **must** be Travel Safe. If not they are not durable because they will sooner or later have to be made safe. Have not the railroads had to inaugurate safety devices and adopt safety methods of construction?

Observation on a Highway

The writer has for almost a year observed the condition of travel on a certain highway to one of our cantonments located 12 miles from the city. The traffic on this highway was considerable, but no greater than the same highway will be compelled to handle at certain occasions when it is linked up with other highways. Evidences of new accidents were observed on every one of the numerous trips made over this highway. In mentioning this fact to the Major in charge of Building and Construction the writer was surprised to hear him make the statement, that there was an average of an accident each day.

The climax, however, came a little later when the writer discussed the matter of widths of highways with one who was interested in highway construction. His belief was that 12 ft. pavements would be amply wide enough in many instances and defended his theory by offering as evidence the practice of some of our eastern states.

A further search for evidence, or rather an excuse for narrow pavements, resulted in finding locations of 10 and 12 ft. widths, but no evidence was found to substantiate the theory that they are safe or economical, excepting in remote communities where there is but occasional traffic.

Views of Others

A few views of others on this matter may be advisable and I am glad to quote Mr. G. Robert Ramsey, Assoc. Member American Soc. C. E., Consulting Engineer, Orlando & Tallahassee, Florida, from an article entitled, "Lessons Taught by Road Building Experience in Florida," and appearing in the February, 1919, issue of Municipal and County Engineering.

"Many miles of brick highway have been built in Florida. Unfortunately many of these roads are only 9 ft. in width. * * * Florida has come to the realization of what her road systems mean to her and the roads that have been built are but the forerunners of what is to come. The road of the future will be better and of sufficient width to permit of the passing of two vehicles."

Also Ray N. Case, County Engineer, Ashtabula County, Jefferson, Ohio, in an article entitled, "The Brick Highways of Ashtabula County, Ohio," in the same issue of Municipal and County Engineering, says:

"In 1915 the first 10 ft. brick roads were constructed. In that year 25 miles were placed under contract. These roads were designed 10 ft. in width, 9 ft. of brick with flush curbs 6 ins. in width and upon 4½-in. gravel concrete foundation, using 1½ in. sand cushion with crown ¼ in. to the foot. This type of road constitutes our greatest mileage, and while some criticise the narrow road, it nevertheless is the highway for rural districts."

He also says "a 16 ft. highway on main roads where there is a heavy automobile traffic would be more desirable."

I also wish to quote Mr. Case in another part of his article because it has a particular bearing on this matter of widths which we are discussing. He says, "No matter how unimportant a roadway be before it is improved, it at once becomes a main highway when improved."

Also in another article which is said to reflect the ideas of the New Jersey Highway Commission the statement is made: "Hard pavements will be not less than 18 ft. wide. In addition there will be 3 ft. stone shoulders on each side, making in effect 24 ft. pavements. There will be 3 ft. earth or gravel shoulders, making a total of 30 ft. of carriage or travel way. On the main, heavily traveled routes are being laid concrete pavements 8 ins. thick at the sides and 10½ ins. thick at the center. On secondary routes are being laid 6 in. concrete pavements at the side and 8½ ins. thick at the center. Where asphaltic brick or stone block pavements are used they will have concrete foundations not less than 6 ins. thick except in the more isolated sections where traffic will not be heavy for many years, asphaltic pavements will be laid upon existing macadam bases, where same exist of proper width and depth. None of the state highways will be paved with macadam or bituminous macadam, or any other material inferior to asphalt or concrete.

"A sincere effort is being made to build for the highway traffic demands of tomorrow. In alignment width, grade and pavement, the viewpoint is that we are building for a long time to come and the best obtainable, within reasonable limits, should be had now."

In no instances has the writer found supporters for the narrow roadway movement making their claims in favor of them without offsetting them by saying they were for light traffic in remote localities only.

Much Traveled Roads Must Be Wide

Are we paving our highways in remote localities or

are we paving them where traffic is greatest and likely to be needed most? This movement is primarily intended to take care of our heaviest and most intense traffic. We don't need pavements in isolated territories excepting in very rare cases, but we do need many miles of them between our principle cities and neighboring towns.

Speed and Clearance

We all know that these highways will be required to handle our heaviest and largest trucks as well as all other sizes and kinds of vehicles. These highways must be designed to carry these loads and to handle them safely. They should safely handle traffic going at the rate of thirty miles per hour. This is the speed limit set by numerous states and seems to be the speed that will be universally accepted. To make this speed less will impair the value of the highway as a rural thoroughfare. To handle traffic at this speed or even at 20 miles per hour will require at least 2 ft. for clearance between the vehicle wheel and the outer edge of the pavement. In observing traffic on highways the writer has observed that this is generally the case. I believe any driver will agree with me that he will not run much closer than this to the edge of the pavement when going at such a rate of speed. Earth shoulders are seldom in such a condition that one can safely allow one wheel to run off of the pavement. To be sure there are places along the highway where this is safe, but it is not likely they will occur where it becomes necessary to pass other vehicles.

This being the case and knowing that we must have even a greater clearance between two vehicles going in opposite directions, it becomes a simple matter to determine a minimum width required. As in the case above, the writer has also observed that 4 ft. makes an average clearance between vehicles.

An average motor car will measure 6 ft. wide overall. We will now add together 4 ft. for clearance at both edges, 12 ft. for two cars and 4 ft. for clearance between them, and we have a total width required of 20 ft.

Having measured trucks which measure 8 ft. in width, the writer does not feel that this width would be unreasonable. Furthermore, some drivers cannot drive as steady as others, and some trucks or cars are not so easily managed as others. Assuming two of these large trucks passing each other we have only a total clearance of 4 ft. or say 1 ft. on each side of the roadway and 2 ft. between trucks.

No Economy in Narrow Roadways

As to economy of the 18 ft. roadway, the writer does not believe that there is any economy. Assuming a price of $4 per square yard for the paving, a 20 ft. roadway would cost about $46,932 per mile, an 18 ft. roadway $42,240 per mile, showing a saving of about $4,692 per mile. This saving will have to be spent on additional care of earth or gravel shoulders and will without doubt be spent in two years time.

As to narrower widths, it may be said they are entirely inadequate, dangerous, and will be expensive to maintain.

Traffic, ordinarily when not confined to one side of the highway on account of passing other vehicles, will distribute itself more evenly over the entire surface of a broad highway than in the case of very narrow roads, where the traffic follows the same line continuously. In the case of 10, 12, 14 ft. roadways this is very readily seen. Marks on the pavement soon show that all vehicles follow the same path. When this path becomes worn it cannot be repaired without causing a great deal of discomfort to the traffic. Under the same traffic the narrow roadway cannot give the same wearing qualities as the two-way traffic road of 18 or 20 ft. width.

While the writer has attempted to show that 20 ft. is not an unreasonable minimum width, there will be many instances where greater widths are important. It is the writer's conclusion that our highways should be paved not less than 20 ft. wide.

THE DESIGN OF PAVEMENT SURFACES FOR MODERN TRAFFIC

By H. J. Fixmer, Division Engineer, Board of Local Improvements, Chicago, Ill.

The design of pavement surfaces for modern traffic is an interesting study and merits more careful attention than is generally given to it. The value of the pavement to the users must be considered of paramount importance. The ideal pavement surface must prove safe and comfortable to use, must be truly economical and present an agreeable appearance. We must consider not only the effect of the traffic on the pavement, but the effect of the pavement surface on the user. We must design our pavement surfaces to fit the needs of the traffic. A pavement is judged by its surface.

Three Classes of Traffic

There are three general classes of traffic, namely, pedestrian, horse-drawn and motor. In some instances one or possibly two classes of traffic may be ignored, but in the typical town or city street all classes must be given due consideration. Since all three classes have a right to use the street, the ideal pavement must be designed to afford each class the maximum of comfort and safety without interfering with the right of comfort and safety of the other two classes. On a given street the relative importance of the various kinds of traffic must be determined. Since horse-drawn traffic is slowly but surely decreasing, less attention need be given to accommodating this traffic. Modern traffic may be considered to consist of pedestrian and motor-driven vehicles.

Provision for Pedestrian Traffic in Chicago

Provision must be made for pedestrian traffic at all street, alley and private driveway crossings. Comfort and safety must be secured. These are secured by eliminating steps as far as possible, avoiding gutter openings in the path of traffic, providing a smooth surface as nearly straight and level as practicable, and keeping the crossing clean and dry.

Considerable study has been given this subject in Chicago in recent years, and it is believed successful, if not ideal, results have been achieved. On streets designed by the writer the usual step from the abutting sidewalk to the pavement surface has been eliminated at all alley, private driveway and street crossings in residence districts.

On business or through traffic streets considerations of safety and the greater importance of vehicle traffic modify the general plan. On all street, alley and driveway crossings along such a street the pavement is built even with the sidewalk for a distance of at least 6 ft. nearest the building line. A step of from 5 to 7 ins. is made at the curb adjoining the cross-walk crossing the busy street. By eliminating the steps along the street the maximum pedestrian traffic is accommodated with little interference with the comfort and safety of the slow-moving cross vehicle traffic. The step at the cross-walk crossing the business street permits the pavement surface to be carried through on a nearly level grade, which accommodates the maximum vehicle traffic. The presence of the step tends to cause the pedestrian to hesitate (and look) before crossing the busy street. Where the street is of unusual width or carries a great volume of fast-moving traffic a safety island is often built. The island is usually 4 ft. wide and 6 ins. above the pavement surface. Where two car line streets intersect, the usual step at the cross-walk is eliminated, since all vehicle traffic must slow down in crossing, and because the large pedestrian traffic at this location demands a comfortable crossing. Where a vehicle is traveling less than 15 miles per hour the slight raise in the pavement surface occasioned by the so-called "flush cross-walk" causes no inconvenience or noticeable jar.

Street Crossings

The importance of a smooth surface at street crossings was early recognized. In the old granite block pavement crossing slabs were laid. In the old macadam pavement brick cross-walks were built. In the typical village or small town the first street improvement generally consists in building a plank, stone or concrete cross-walk. Time has proved them very undesirable, as they soon become uncomfortable and even dangerous to vehicle traffic. Since modern vehicle traffic requires a smooth surface, it is found that a modern pavement agreeable to such traffic is satisfactory to foot traffic.

The crossing should be as level as is consistent with the contour of the pavement and with surface drainage. This means a fairly flat crown.

The crossing should be clean and dry. By reason of paving the crossing even with the sidewalk, with a low crown and slightly increasing the slope of the gutter away from the crossing, the crossing keeps clean and dry automatically. Where a step is necessary it is a refinement worth while to increase the gutter slope across the cross-walk to enable the gutter water to pass without depositing any refuse at the crossing.

Little consideration is now given to horse-drawn traffic in the city except at grades and at localities of heavy trucking. The horse is little used for pleasure driving, and since he travels slow the demands of comfort and safety are of little weight. For horse-drawn traffic the pavement surface should be fairly smooth, non-slipping, and, on all grades and loading areas, afford a good foothold. A resilient surface is recognized as better for the horse, but since he is gradually disappearing from general use it is advisable, as a general rule, to ignore his peculiar needs.

Surfaces for Motor Traffic

Motor traffic, both pleasure and trucking, is the type of vehicle traffic we must design our pavements to meet. Comfort and safety must be secured. The surface should be smooth. It should be of adequate width. It should afford low tractive resistance. It should have a low crown, easy grades, easy turns and an agreeable appearance.

A smooth surface implies freedom from surface irregularities such as appreciable joints and cracks; unevenness due to surface wear or disintegration; unevenness due to debris dropped or accumulated, settlement of the structure underneath, and contour unevenness due to raised crossings, change of grade, and crown slope not adapted to the location. The matter of proper width will not be discussed, except to point out that it is usually determined by the amount of money available rather than a careful analysis of the amount, kind and speed of the traffic expected to use the pavement.

The matter of subsoil drainage, preparation of the subgrade and design of the pavement structure will not be discussed except to point out that these are distinct from the design of pavement surfaces, and that the function of these is to secure and maintain a smooth surface. To have a good surface the pavement must be properly repaired, maintained and cleaned.

The importance of cleanliness is obvious in the city, but it is likewise important on country roads, from other than reasons of sanitation and appearance. A clean surface, being non-slippery, promotes safety. Recent experiments have shown that irregularities of surface due to unevenness and foreign material dropped by passing vehicles, or even accumulated refuse, induce, by increased impact, excessive strains in both the surface and pavement structure. A pavement properly maintained and cleaned, apart from increasing its life, safety, comfort and agreeableness to the user, can carry at least twice the load that a neglected surface can.

A pavement should have as low a crown or cross slope as conditions will permit, in order to encourage full use of the surface width. At intersections the crown should be carried through without inconvenience to the vehicle traffic on the more important street.

The character of the pavement surface should be varied to suit special conditions. In front of schools, libraries and hospitals a quiet surface is appreciated. On grades a surface that will give good traction, and possibly good foothold, is needed. At turns where proper superelevation cannot be secured it is often advisable to use a gritty surface and keep it clean. In other words, on any improvement the character of the surface, like the depth and strength of the pavement structure, must be adapted to the locality and to the requirements of the users.

Large radius corners should be used, as they promote safety, reduce congestion, reduce curb breakage and add to the comfort of the user. All abrupt changes in grade should be connected by vertical curves. All horizontal curves should be of large radius on through streets and properly eased at the tangents. Proper lighting, tree planting and street and route markers, add to safety, appearance and comfort.

Smooth Surfaced Pavements

Pavements that have a smooth surface or can be easily maintained and cleaned may be arranged in the following order:

Sheet asphalt on concrete base; asphaltic concrete on concrete base; brick with asphalt filler and concrete base; concrete with asphalt filled joints and cracks; creosoted

wood blocks as usually laid; sandstone blocks with grout filler; granite block with bit. mastic filler; brick or granite with grout filler; brick or granite with tar filler; asphalt macadam; water-bound macadam; and clay-gravel surface.

The foundation structure should be designed to fit the traffic and character of the subgrade. Its function is to support the surface. The surface should be designed to fit the needs of the location and the users. And these needs are, may it be repeated, comfort, safety and appearance.

The foregoing paper by Mr. Fixmer was presented at the annual meeting of the Illinois Society of Engineers.

EFFECT OF CAR TRACKS UPON TRAFFIC CAPACITY OF ROADWAYS

By Geo. W. Tillson, Consulting Engineer, 313 S. Catherine Ave., La Grange, Ill.

There is probably no one thing that is the source of so much trouble and annoyance to the official in charge of the maintenance of street pavements or road surfaces as the existence of street car tracks in these surfaces. This is mainly true because he has no direct control over the repairs required to keep the tracks in good condition. As a general rule the street car companies must keep in good repair the tracks and pavement between them as well as for a short distance outside. It is generally provided also that, if the corporation does not do this, it may be done by the municipal authorities. But the procedure is such, and so much red tape is involved in carrying out the legal requirements, so that the cost of repairs may be collected from the company, that the provision is seldom resorted to and it is generally considered better policy to try and have the necessary work done by the corporation itself.

Car Tracks in Street Often Necessary

While as has been said the existence of car tracks in streets and roads is annoying, the public authorities accept the fact that they are necessary. Transportation is a very important factor in any community, be it large or small, whether a city or a state, and it does not seem proper that existing routes of travel should not be made use of wherever possible. It may be said of course that street car lines especially if suburban should secure their own rights of way. This may be true, as an abstract proposition. But it should be remembered that this involves a considerable increase in capital cost and to such an extent reduces the dividend to be paid from a certain fixed fare. This is exceedingly important at the present time when so many street car companies both urban and interurban are finding it impossible to meet their financial requirements with their franchise rates of fare.

The acceptance of this fact, however, does not mean that tracks are to be laid at any place or in any way as the company sees fit without regard to the public rights or needs; far from it, but quite the reverse indeed.

A discussion of the subject of this paper must necessarily be academic to a great extent; but it is hoped that the presentation of one or two concrete cases will be sufficient to illustrate the general idea.

Principal Items to Consider

The principal items to be considered in this connection are: the location of the tracks, their detailed construction, their degree of perfect maintenance, the character and amount of traffic on the tracks, and the character and amount of traffic on the street or road. The question of location is perhaps the one to be most considered as upon the location depends the importance of the other items. Its discussion too involves the problem of what is the best location for car tracks when they must be laid within the lines of streets or roads. The common practice with streets is to place them in the center, thus giving an opportunity for streams of traffic to move in either direction entirely independent of each other. With this arrangement it can easily be seen that the width between the cars and the curb will have much to do with the effect on traffic. In the Borough of Brooklyn, New York City, many street with roadways only 34 ft. wide have two lines of car tracks and some with a width of only 30 ft. In such cases the obstruction to traffic must be very great as the distance from track to curb is only 9½ and 7½ ft. respectively and even these distances are reduced by the overhang of the car itself. It is on streets like these that the items of construction, maintenance, amounts of traffic, etc., are particularly important.

The writer has always felt that a car track should be so constructed in a pavement that vehicular traffic could pass over it diagonally, squarely or in any direction without any real inconvenience, and that it should be so maintained that it would always meet this requirement. The heavy truck traffic that is so constantly increasing emphasizes this idea. With the present standard rails and latest construction there is no difficulty in meeting what is desired. Practically all electric roads in streets or highways are operated by overhead trolleys but in the Borough of Manhattan, New York City, where the underground trolley is used, it is necessary to have a slot half way between the rails of each track. This is also true of cable roads. Such construction makes is very difficult properly to maintain or lay the pavement. The space between the slot and rail is so narrow and so shallow over the conduit that carries the power that ordinary pavement methods are not successful. With the same amount of care in construction and maintenance such tracks are more of an obstruction to traffic than those used with the overhead trolleys. The writer once saw both in Brussels and also in Vienna an underground trolley system where the slot was built in connection with one of the rails leaving the entire space between the rails unbroken. This seemed much better work from a pavement standpoint but the engineer in charge of the railways of Vienna said it was not good for operation. Why, this was not explained but it was thought that possibly it would not permit so good an electrical connection with the car.

Some Specific Examples

The Board of Estimate of the City of New York has made a rule that a double track road shall not be laid in a street with a roadway of less than 40 ft. In Philadelphia where the streets are narrow generally but one track is laid in a roadway, the cars necessarily having different routes to and from the center of the city.

In some cases where tracks are laid in the center an area is curbed especially for the tracks, vehicular crossings taking place only at cross streets or other especially provided places. This is true in a few other cities, but almost generally so in New Orleans. Here the streets as a rule are wide, allowing plenty of room for this method

as well as for the general traffic of the city. In such cases, of course, traffic is not impeded at all except as to general crossing from one side of the street to the other.

Rochester, New York, has one or two streets where the tracks are located just inside the curb line. On one of the streets leading out of Paris the writer once saw a similar location. In Rochester the instance noted was on a distinctly residential street but in France it was in a small retail section.

With such a location the general street traffic would not be effected but it has always seemed to the writer that it must be very inconvenient to the people along the line, especially if it was on a business street. Here, however, again comes in the question of how much traffic the car line carries and how often the cars run.

Perhaps the best example of obstruction to traffic by car tracks of which the writer has any cognizance is in the Borough of Manhattan, New York City. Central Park West is that portion of Eighth Avenue lying directly west of Central Park. This Avenue south of 58th street is 100 ft. wide with a 60 ft. roadway with car tracks in the center. Central Park West is also 100 ft. wide but the roadway is only 48 ft. wide and the tracks are laid on the easterly side, the nearest rail being 3 ft. from the curb, leaving a free roadway of 20.9 ft. not taking into account the overhang of the car.

A New York Street

Central Park West is built up on the west side with business houses on its southern end and the remainder with large apartment houses. The cross streets too are well built up so that the local traffic is heavy. Previous to the introduction of the automobile the obstruction to travel was not so great. But it can easily be seen that with it being necessary for all pedestrians to cross two lines of vehicular traffic in order to take or leave a car a great deal of trouble must occur. So many accidents occurred that in 1913, the Board of Estimate and Apportionment passed a resolution directing the Railway Company to relocate the easterly track at its own expense with the intention of widening the roadway after this was done. It seems, however, that the tracks were located in their present position in 1897 at the request of the Park Commissioner of the City and the Corporation Counsel advised that a court seeking to do equity might well deny the application to compel the Company to again relocate its tracks entirely at its own expense. The estimated cost of the work was $352,000. Many communications passed between the City and the Railway Company in regard to the matter but no physical work was ever done and the tracks and roadway still remain as herein described. The police reports show that on this street 286 accidents occurred during the years 1910 to 1913 inclusive. In addition to the accidents to persons the Police records show that in 1913 there were 36 collisions between vehicles and 8 collisions between vehicles and surface cars. It is also stated that probably only the most serious vehicle collisions are included in the police records. No doubt the number of accidents have increased in subsequent years. In any event, recently Central Park West has been made a one way street so as reduce the number of accidents to a minimum. In order to understand just what this means it must be remembered that Central Park extends in width from 5th avenue to 8th avenue, a distance of half of a mile, and that by making Central Park West a street for south bound traffic only this distance is increased by one long block so that all north bound traffic is cut off between 5th and Columbus (old 9th) avenues. This of course increases the congestion on all north and south avenues. North bound automobile pleasure traffic, although permitted to go through Central Park, has but two outlets to the west so that if not through traffic it must be seriously inconvenienced.

Other New York Streets

Compare for a moment the situation on Fifth avenue south of 59th street. This street is also 100 ft. wide and prior to 1908 had a roadway of 40 ft. with sidewalk spaces 30 ft. wide, but areas and stoops were allowed to encroach 15 ft. so that the free width of the street was only 70 ft. The Board of Estimate and Apportionment by resolution widened the roadway by setting the curb back 7½ ft. on each side and ordered the encroachments back to within 2½ ft. from the property line, thus giving a roadway 55 ft. in width with sidewalks 20 ft. wide free from obstruction. The old roadway permitted four lines of traffic while the additional 15 ft. in width furnished space for two more and even this is insufficient for the traffic requirements.

The large cars of the Brooklyn Rapid Transit Company, when passing occupy practically 19 ft. of space, 18.6 ft. to be exact. Supposing a double track line were laid in the center of 5th avenue, with the traffic it would certainly have when two cars met there would be left on each side a distance of 18 ft. only sufficient for two lines of travel, in other words, nearly all of the benefits of the widening would be lost.

Prospect Park, Brooklyn, has five sides and on all of the adjacent streets there are street car tracks. With one exception the location is similar to that on Central Park West. But on only one street, Prospect Park West, has it been necessary to establish a one way traffic. This is because both the local street car, passenger, as well as vehicular traffic is light. During the summer a large part of passengers carried by the car lines have the park itself as an objective and they of course are benefitted by having the tracks adjacent to the curb. The situation as a whole, however, well illustrates the bearing of both kinds of traffic upon the subject under consideration.

In another, but perhaps indirect, way can be shown somewhat how traffic is diverted on street car streets, and that is by its effect upon the pavements.

In the Borough of Brooklyn careful records have been kept of the cost of repairs to all pavements for more than 15 years, by individual streets.

The cost of repairs to asphalt pavements on streets without car tracks for the years 1914 to 1918 inclusive has averaged 2 cts. per sq. yd. and for streets with car tracks the cost has been 3.4 cts. While these figures prove nothing directly they are at least indicative as they give results upon 31,645,000 and 3,884,000 sq. yds. of pavement on streets without and with car tracks, respectively.

Tracks on Country Roads

The problem of track location on roads is somewhat different from that on streets as the local conditions are so different. Then, too, a country road, even if paved, seldom has its pavement of greater width than will accommodate expected vehicular traffic so that any interfer-

ence with existing pavement will be serious. Fortunately, however, there are generally no very serious objections to a side location, the tracks being sufficiently far apart to provide for ample width of the pavement between them. The new National Highway bill proposes, where feasible, a 66 ft. width of right of way and a pavement width of not less than 20 ft. This would give ample room for car tracks on both sides of the pavement. Whenever a wider roadway is required or any special local conditions arise each case must be considered on its individual merits.

If the tracks are located in the pavement whether in a city street or country road the shape of rail and method of construction become very important. As has been previously stated the mere existence of tracks in a pavement should not interfere with traffic. As a matter of fact they do. The writer some 25 years ago saw a track on 14th street, Borough of Manhattan, laid with two center bearing rails instead of one laid on longitudinal wooden stringers, the rails and tracks being so near and of such construction that traffic in the center of the street was almost entirely cut off. Fortunately such conditions do not now exist anywhere, but they illustrate the importance of the principle.

Type of Rail

No doubt the well known T-rail of the steam roads is the most economical type of rail for traffic. It does not, however, permit a smooth junction between the pavement and the rail either between the tracks or outside. This type of rail also is liable to cause ruts alongside the rail if the tracks are much used by vehicles. With the present grooved rail in use in most cities with a practically square edge on the outside and the flat lip on the inside, it is perfectly practicable to construct a track that *per se* will not interfere with traffic, especially if a 60 ft. rail be used. Specially burned brick or specially cut stone blocks are sometimes used in connection with the T-rail, the groove being really cut out of the blocks. This method often produces good results. On a country road where the tracks are laid outside of the pavement the T-rail can of course be used to advantage.

But whatever the style of construction it should be designed with the idea of keeping both the track and pavement in good condition. Unfortunately the track area of pavements in American city streets are not generally in good condition. Much improvement however, has taken place during the last 20 years and most street railroad companies realize that it is good policy to keep their plant well maintained. Again, unfortunately, soon after this realization the world war came on bringing with it financial changes to all but which seemed to injure street car companies more than almost any other corporations, bound as the most of them are by franchise obligations as to permissible fares with costs of labor and materials mounting up with aeroplane-like rapidity.

Conclusion

If, then, car tracks are to exist in paved streets or roadways they should be so constructed as to present as little interference as possible with the pavement.

Perhaps the most important item in construction is the type of rail to be used and this has previously been discussed.

The road bed and foundation too must be specially prepared. The rail must not give appreciably under car traffic as it is almost impossible to maintain any pavement against a rail that moves vertically under the passage of cars.

The joints, too, are a prolific source of trouble. Many times a hole in a pavement along the track has its origin at a defective joint. The use in the last few years of a 60 ft. rail has helped this situation very much. Admitting the force of the arguments used herein, it follows that street car tracks do obstruct traffic very materially when in use in streets or roadways.

It also follows that the extent of this obstruction depends upon the amount of existing traffic and location of tracks, being greatest where both tracks and roadway are used to their utmost capacity and the tracks laid in the pavement, and almost nil where traffic is light and the tracks located outside of the pavement proper. Probably no better illustration of the relative traffic capacity of street car and non-street car streets can be given than existing conditions on Jackson Boulevard and either Adams or Madison streets in the loop district of Chicago in the rush hours.

In designing a street or road where provision must be made for street car lines, a study must be made of both street car and vehicular traffic, present and prospective, so that the relative importance of each may be determined. As a general proposition the center of a paved street will be the correct location, but often special conditions may make a different one desirable. In the same way it might be said that on a country road the side location would be most logical, changing somewhat, possibly, when passing through small towns or villages.

Wherever the location the type of construction should be good, variations being permitted according to exact location and character and amount of traffic.

As careful provision should be made for the maintenance of the tracks and pavement to be kept in repair by the street car company, if any, as for the roadway pavement itself. The writer knows that this is often difficult but thinks that unless the Company is operating under a franchise giving it special privileges, good results can be obtained by some arrangement. If a new franchise is to be issued, the car company might be obligated to pay a specified amount with the understanding that the Highway authorities would keep the pavement in repair. The maintenance of the tracks and road bed must be left to the operating company.

The writer feels, therefore, that if these precautions are taken that while some traffic obstruction must, exist, it will in this way be reduced to a minimum and the general traveling public benefited as much as possible.

The foregoing paper by Mr. Tillson was presented before the 1920 annual convention of the National Highway Traffic Association.

SEWAGE DISPOSAL IN SMALL CITIES AND TOWNS

Written for Non-Technical City Officials

By Milton F. Stein, Civil Engineer, Chicago, Ill.

The necessity for sewage disposal works is more generally and more urgently felt in the smaller towns

at present than in the past. In some cases this is due to growth in population or more complete sewering, which has rendered former disposal works inadequate, or may have so increased the quantity of sewage as to cause nuisance and protest from dwellers along the watercourse into which it is discharged. Then again, an increasing number of small towns and villages are installing public water supplies, after which sewers follow as a matter of course, and the question of sewage disposal arises quite naturally or is forced upon the attention of these prospering and progressive municipalities by the proper state health authorities. To these reasons may be added the increasing appreciation of the importance of sanitation; and the continued improvement in practical sanitary methods, which has raised sewage disposal projects from the status of rather dubious experiments to that of matter-of-fact accomplishments. It, therefore, follows that many of the smaller towns are being confronted with the problem of building new disposal plants, or remodeling old one, which may be obsolete, inoperative through neglect, or outgrown.

The problems of sewage disposal for small towns are peculiar, and often differ considerably from those of the larger cities, if for no other reason, because the latter are usually located near some stream or watercourse of considerable size, whereas the location of the former is often dictated by some primary cause, such as the junction of two railroads, which may leave them high and dry insofar as a stream suitable for sewage purposes is concerned.

Mental Attitude Toward Sewage Disposal

The sanitary engineer cannot but be impressed with the popular mental attitude toward sewage disposal, as reflected in many instances by the municipal officials with whom he comes into contact. It is most important that this be corrected if necessary, as upon the proper point of view on the part of the municipal officials depends very largely the success or failure of any sewage disposal project. In the past there has been the very general thought, which still persists to some extent, that the average citizen's responsibility for the disposal of sewage ended with the connection of his house drains into the street sewer. If an officious state health board insisted on disposal works, these were built as cheaply as possible, and as remotely from human habitation, often adjacent to the municipal garbage dump and rubbish pile, and if not completely forgotten forthwith, were subject only to very occasional visits by some minor employe. This attitude has happily changed for the better to a large extent, but is still occasionally met with, and its results are, of course, existent in the form of disposal plants, which because of poor design and construction, and subsequent neglect, are useless, or worse.

It may seem rather impertinent, but it should nevertheless prove beneficial, briefly to outline the more basic principles of which the average municipal officials' mental attitude toward sewage disposal should be compounded.

There must be appreciation of the fact that the sewage from his town may constitute a nuisance to other communities, ranging from a mere affront to esthetic susceptibilities to an actual health menace. No town has the right to inflict such conditions on its neighbors, and in this matter faces a duty that it should not try to evade, as to do so would be detrimental not only to the general health but to common progress and betterment.

There must be reliance and confidence in the ability of the state health authorities to decide upon the existence of such a nuisance and upon its degree of seriousness, and a willingness to carry out their recommendations in a whole-hearted manner.

It must be realized that the art of sewage disposal is on a scientific basis. Many past failures have resulted from use of rule-of-thumb methods. The processes and reactions involved should be carefully studied for each specific case, and a special plan of procedure, based upon a thorough investigation and analysis of conditions, should be decided upon.

There must exist the resolution conscientiously to carry out the accepted plan in all respects, especially as regards the construction work, as any skimping may seriously affect subsequent operating conditions and even the durability and ultimate life of the disposal plant.

Cognizance must be taken of the fact that no sewage disposal plant will operate and maintain itself, and therefore any project must include the provision of an annual sum for operation and upkeep, the amount of which should be based on the opinion of someone versed in such matters, perferably by the engineer who has been entrusted with carrying out the project.

Making the Most of Old Plants

The writer is of the opinion that there are a considerable number of disposal plants which, though not up-to-date, are mainly inoperative through neglect, and with proper attention can do useful work for a number of years, or until they can be supplanted by modern plants. In many cases the first requirement is a thorough cleaning and overhauling, with minor repairs, and the washing and perhaps partial replacement of filtering materials. Where the plant has been outgrown, provisions can be made for treating sewage up to its capacity and by-passing the remainder. Certainly it is better, as a temportary expedient, to treat a considerable portion of the sewage, rather than to pass the whole of it through the plant in such a manner as to afford no treatment at all, as is usually the case in these obsolete and neglected plants. The important point, after overhauling is to give proper and intelligent care to the operation, which has often been more at fault than the obsolescence and inadequacy of the plant.

Selecting Type of Sewage Disposal Plants

Those contemplating new disposal plants, or extended remodeling of existing ones, are very likely to be confused by the newer developments in sewage treatment, which have been very widely discussed in the technical press of recent years. The last decade has seen the Imhoff tank supercede the septic tank, and the trickling filter has been in general use but little longer. Two more recent developments have been the activated sludge process and the fine-meshed mechanical screen.

Some credence has been given to the opinion that fine-meshed screens could compete on an equal footing with sedimentation tanks of the Imhoff type, whereas, their fields of usefulness are quite distinct and only overlap to a small extent. Where a relatively small amount of sewage is discharged into a large body of water, it is necessary to remove only coarse suspended matter in many cases, as dilution is sufficient to take care of the sewage without nuisance. The removal of coarse suspended and floating matter under such conditions is generally best accomplished by means of fine screens. Where it is desirable to remove a considerable proportion of the suspended matter, settling tanks are necessary. There is necessarily a region where conditions overlap, and where both screens and tanks may be considered with propriety.

There has been some complaint against the Imhoff tank recently, because of odors and foaming in certain instances. Undoubtedly under very abnormal conditions such trouble will occasionally occur. One possible source, which has not received the attention which it should, lies in the design. This is usually based upon a per capita basis—so many units of sludge capacity, settling capacity, etc., per person. On such a basis the propery balancing of the biological activities in the tank is likely to be lost sight of. Probably a more thorough study of each design from the dynamic point of view would be beneficial.

The activated sludge process offers a substitute for the Imhoff tank—trickling filter plant in the complete treatment of sewage. It is more compact and probably produces an effluent of greater purity. Up to the present only experimental plants have been in operation, if we include in that category two or three plants treating the whole sewage of small cities. The difficulties in this process are those of operating under the limitations of practical conditions as against experimental, and the disposal of the voluminous quantity of sludge formed.

As regards the choice of a system of sewage disposal for the town or small city, Pope's rule may well apply:

> "Be not the first by whom the new is tried,
> Nor yet the last to lay the old aside."*

As has been said before, every case requires special consideration, but to give the reader somewhat of an idea as to what plants would be suitable under various conditions, we may generalize as follows:

Where the sewage is discharged into rivers of great volume and rapid current, or into the open sea at isolated points, fine meshed mechanical screens may properly be used.

Where the sewage is received by rivers with a large minimum discharge, not grossly polluted, Imhoff tanks usually suffice.

Where the sewage is of large relative volume compared to the dry weather flow of the water course, in general whenever a town of several thousand inhabitants discharges its sewage into a creek or small river, complete treatment, consisting of coarse screens, grit chambers, Imhoff tanks, trickling filters and perhaps even secondary sedimentation basins, is usually necessary.

*Essay on Criticism, Alexander Pope, 1711.

Measures Preliminary to Construction Important

Of the measures preliminary to a sewage disposal project, the scope of this article prohibiting any discussion of the legislative and financial steps involved, we must limit ourselves to those having direct bearing on the design and construction work.

Most important is the obtaining of a record of sewage flow, and the variations therein, hourly, daily and seasonal. Even if no improvements are contemplated, every town and city should keep an accurate record of its sewage flow, based on daily or hourly measurements. Such data has many important and interesting applications. It furnishes the most reliable information as to the capacity of sewage disposal works required. It is very useful in connection with sewer design. The writer has found that taken in connection with the chemical analyses of the sewage, embracing those determinations which indicate the nitrogen present, it forms a basis for estimating the population of a town and its increase which can only be surpassed by a very carefully taken census. This may seem surprising, except to those who are familiar, through detailed study, with what is popularly called the "law of averages" or more correctly the "theory of probabilities," and therefore are aware that many very complex natural phenomena if due to a large number of causative factors, fall under the leveling influence of this interesting general law. It is usually possible to build a wier near the sewer outfall, and an automatic recorder, with clock driven chart, can be bought at a reasonable price. At least a year's record should be obtained if possible.

Chemical analyses are only second in importance to flow measurements. They can be obtained in much less time, a month being usually sufficient. The writer is aware that he is diverging somewhat from common practice in emphasizing flow records and analytical data, instead of basing the design upon population records, but a sewage disposal works is like a manufacturing plant in that it is required to assimilate a certain amount of raw material daily, and the above measurements are the only ones from which this amount can be accurately computed.

Other preliminary data is that usually covered in the engineer's report and need not be discussed here.

Generally elaborate experimental tests are not called for, but if the above analytical data shows the sewage to be peculiar, for example, due to the presence of large quantities of industrial wastes, then experimental treatment is often justified, and may save money in the end.

Description of a Typical Plant

Very naturally, many municipal officials have but meager knowledge of the details of a sewage disposal plant and of the processes of purification, since their interest in the subject of sewage treatment was only aroused upon assuming office, by the special problems which they found confronting them. It is quite labori-

ous for them to acquire the desired information by a study of the various treatises on the subject or by a search of the technical periodicals. It may not be out of place, therefore, to conclude by very briefly describing a typical plant of the Imhoff-trickling filter type, which, as has been mentioned before, best meets the requirements for complete treatment of the sewage in small and medium-sized towns, and by omitting the filters, leaves the partial treatment plant such as suffices when the effluent is discharged into a fairly large river.

A general view of such a plant is shown in Fig. 1. The sewage, entering from the left side of the illustration, first passes through a screen of iron bars, which holds back large floating matter, such as sticks of wood, large leaves, rags, etc., that might clog the pumps or otherwise interfere with the operation of the plant. The screenings are raked off by hand, and either buried or incinerated. Then the sewage flows through two long, narrow grit chambers, arranged in parallel, wherein the sand and grit settle out. These chambers require occasional shoveling out, for which purpose they are first drained. The grit is inoffensive and may be used for filling around the plant.

The picture shows a pumping station, for elevating the sewage from the grit chambers to the Imhoff tanks, In many cases, where sufficient fall is available, this is not needed. However, some sort of structure to serve as a tool house and office is very desirable in all cases.

The purpose of the Imhoff tanks is to clarify the sewage by removing the settleable solids. They are settling tanks, but peculiar in containing two stories. A typical section is shown in Fig. 2. The sewage flows slowly longitudinally through the upper portion of the tank, allowing the suspended matter to precipitate to the inclined false bottom, down which it slides. At the lowest point is a longitudinal slot which permits the precipitated solids to pass through, but is so constructed as to prevent the gas formed by decomposition in the lower compartment from rising upward through it and interfering with the process of sedimentation. In the lower compartment the precipated solid matter accumulates and is digested by bacterial action. In the absence of light and oxygen and in the presence

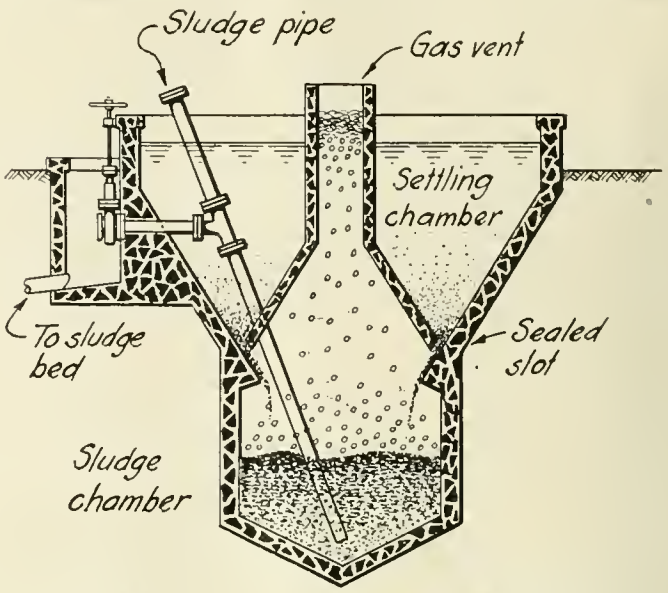


FIG. 2. CROSS SECTION OF AN IMHOFF TANK SHOWING THE PRINCIPAL CONSTRUCTION FEATURES AND MODE OF OPERATION.

of large quantities of organic matter, certain types of bacteria multiply greatly in this lower chamber, and these break up the organic solid matter present into simpler forms, partly gaseous, which escape through the central gas vents, and partly solid which remain. During the summer months this accumulated solid matter is drawn off at intervals through the sludge pipes and allowed to flow over the sludge beds, two of which are shown in the foreground of Fig. 1. Here it is dried by the sun, leaving a porous, grey, spadeable residue, very like rich black soil, and suitable for the same purposes.

The clarified sewage flows from the Imhoff tanks to two dosing tanks, which are equipped with automatic

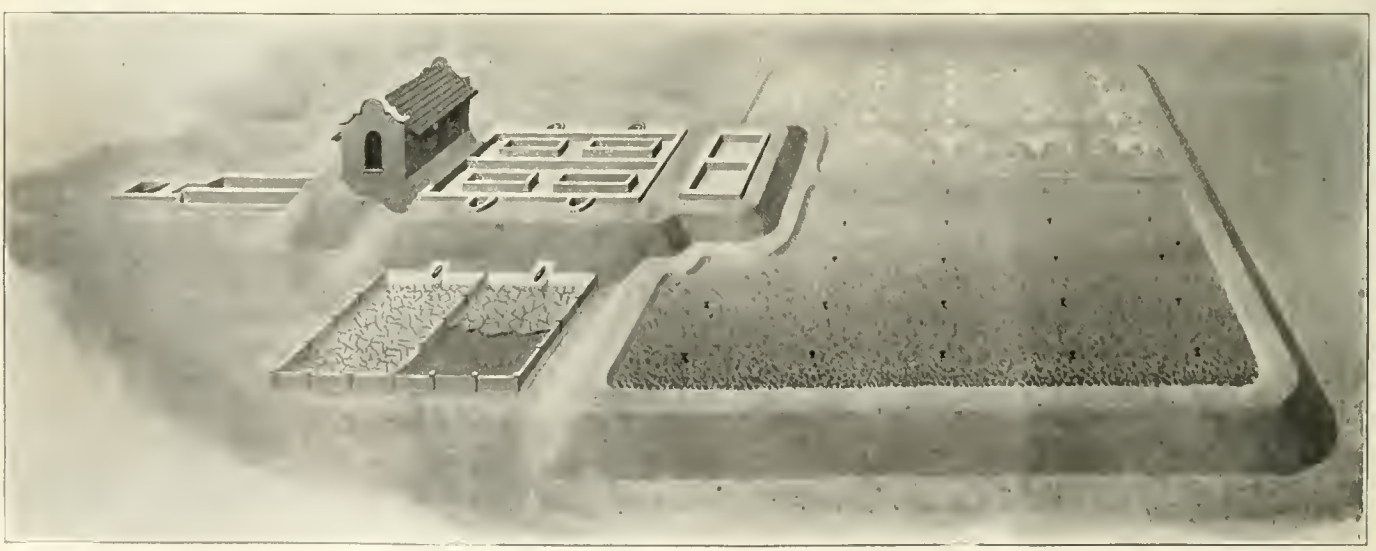


FIG. 1—GENERAL VIEW OF A TYPICAL SEWAGE DISPOSAL WORKS SHOWING, FROM LEFT TO RIGHT, BAR SCREEN, GRIT CHAMBERS, PUMPING STATION, IMHOFF TANKS, DOSING TANKS AND TRICKLING FILTERS, WITH TWO SLUDGE BEDS IN FOREGROUND.

syphons, whose purpose is to discharge it intermittently and alternately into the pipe system which distributes it over the trickling filters. The distribution is effected through regularly spaced nozzles, which spray the sewage uniformly over the whole surface of the filters. Fig. 3 shows a section of the filters. The filtering material, approximately 6 ft. thick, is coarse crushed stone or slag. The sewage trickles slowly down through this. Bacterial action plays an important role here also, but oxidizing bacteria prevail. The

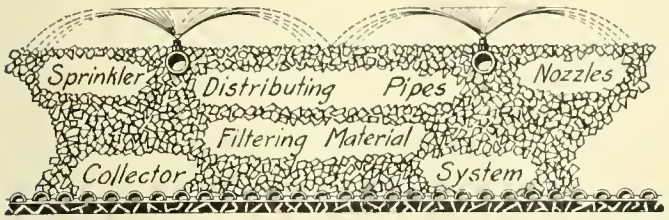


FIG. 3. SECTION THROUGH A TRICKLING FILTER SHOWING DISTRIBUTION OF SEWAGE THROUGH SPRAYING NOZZLES, THE FILTER BED AND UNDERDRAIN SYSTEM.

process involves, first the removing of fine colloidal matter from the sewage, and then the oxidation of this and part of the dissolved putrescible matter into a stable condition. The filters are underlain with a collector system and drains, which discharge the now purified sewage into the stream or river. This effluent is fairly clear and non-putrescible.

At times trickling filters will unload or discharge the accumulated solid matter with the effluent through the drains. Where it is not permissible to have this enter the stream, secondary settling tanks must be installed after the filters, where this may settle out. It is a humus-like material, somewhat like the Imhoff sludge, only much more watery.

Where the effluent enters a river the water from which may be used for drinking purposes further down, it should be disinfected, which may be done by the use of either hypochlorite of lime in solution or by the application of chlorine gas.

IMPACT TESTS ON ROADS

By C. C. Wiley, Assistant Professor of Highway Engineering, University of Illinois, Urbana, Ill.

There is probably no detail of pavement design receiving anything like the attention at the present moment that is being given to the determination of the thickness and make up of the slab. This is as it should be, for with the estimates placing the funds available for road work in 1920 at better than $600,000,000 and with enough city pavement work in sight to push the grand total beyond the billion mark, and with the prospect that the figures will grow in the future it is absolutely imperative that we build with the greatest wisdom and true economy. By building too lightly we can waste enormous sums in maintenance and reconstruction and by building too heavily we can work another great waste in time, labor, materials and equipment at a time when they can ill be spared. And since the cost of right of way, grading, etc. is nearly independent of the pavement detail it is evident that aside from the width of the slab it is the thickness that controls the expense. It is therefore only just that this question should be receiving unusual attention.

Must Design Roads to Carry Trucks

A scant fifteen years ago we faced a great change in road design in changing from the accepted types for horse drawn traffic to those which would serve under the high speed motor vehicle. And here again when we have barely reached a solution of the problem we are confronted with a new and more difficult one for the budding automobile has blossomed into the motor truck and highway transport is an established fact. We therefore find ourselves now facing the unfortunate and dangerous condition of being compelled to expend great sums in construction while readjusting our designs to a new class of traffic which exerts a different destructive action on the roads than that with which we are familiar. We must therefore learn to design our pavements so that under given conditions of climate and soil we will know they are adequate for the loads just as we can design our bridges to be adequate under the same conditions.

How About Highway Bridge Design?

In the early days of bridge building "rules of thumb" served instead of design, but as loads increased these were not adequate. Study and test revealed methods of strict analysis and the adequate design of parts. But even then results were not wholly satisfactory and a little observation and study showed that a train although running on smooth steel rails set up impact stresses. Further investigations indicated the magnitude of these stresses and in all good designs they are allowed for. At the present time, however, the impact allowances on highway bridges are generally determined by the same rules as for railroad bridges, and the question might well be raised here as to whether our highway bridge designs may not need some revision in view of the results being obtained on the actual impact of moving loads on highways.

The Design is the Thing Nowadays

In the early days of road building "b' guess, b' gosh" served for design. In fact, roads were not designed, they were just built, and it is only recently that it is being realized that the designing engineer is fully the peer if not the superior of the construction engineer. But with light loads, slow speed, and low prices the lack of true design was not greatly felt. But with present speeds, loads, and prices, design becomes highly important and it will require only a short ride over a rough pavement experiencing the bumps and jolts, or standing on a hard road while a heavy truck goes by and noting the jar and vibration, to convince anyone that impact surely has some place in the proper design of the structure.

Millions for Construction, but Scarcely a Cent for Investigation

The idea of trying to determine the amount of impact is by no means new. It must have occurred to every road builder of an inquiring turn of mind, and I know for a positive fact that it has been given serious consideration for 15 years or more. But such work requires funds to carry it through, and it is a curious fact that even at the present time, with our enormous appropriations for road work, the amount available for fundamental investigations is discouragingly, in fact almost criminally, small.

Money is available for everything except the fundamental studies on which the safe, sane and economic expenditure of the balance depends. Consequently, practically nothing was done, although experiment stations and highway departments were ready, willing, and equipped to do the work for the bare cost of labor and materials—the brains in general being donated, for rarely if ever have the brains been commensurately rewarded. Finally, however, that small, but highly developed, organization which lies tucked away—in fact, almost buried—in the Department of Agriculture, the U. S. Bureau of Public Roads, fell heir to some funds and undertook the basic studies of the impact on roads.

Basic Studies of Impact on Roads

It is impossible in the brief time available to enter into a detailed study of the data so far obtained by the Bureau of Public Roads, and I shall therefore limit myself to sketching some of the more salient points of the investigation. For the data I quote I am indebted to the article in Public Roads, and other papers by Messrs. Goldbeck, Pauls and Smith, of the Bureau of Public Roads.

Effect of Static Loads

Obviously, the point of beginning of any studies into the stresses in pavements is the determination of the effect of static or quiescent loads. If we assume that a subgrade is incompressible, then the only result of a load is to put compression into the slab, but if the subgrade is compressible, or for any reason fails to support the slab, then internal bending stresses are set up whose magnitude are dependent on the amount of load, the thickness and character of the slab, and the conditions of support. For simple beams and slabs the solution is not difficult, but for the complex conditions affecting a pavement, recourse to tests to determine the factors was necessary. This the Bureau of Public Roads did. (See Public Roads, April, 1919.) Numerous measurements were made, but the most significant is that with a wheel load of 8,500 lbs. on an 8-in. concrete pavement, supported on a subgrade of wet clay of low-bearing capacity, the fiber stress in the concrete amounted to but 34 lbs. per sq. in., or about one-fifteenth of the ultimate strength of the concrete. This load is about equivalent to that of the rear wheel of a 5½-ton truck. If this is true, is it necessary to build a slab 8 ins. thick? If not, why do we do it? If it is, impact must be the answer, at least to a considerable extent, and we will see a little later that the discrepancy is not so large after all.

Two Specific Problems

Assuming that impact is an active factor in road design, the specific problems before the investigators are: (a) The amount of impact delivered to the road surface by different vehicles under different conditions, and (b) the effect of this impact on different types of road surfaces. These are the problems being worked on by the Bureau of Public Roads. The first has progressed some distance, while the second is not as far along.

Test Methods and Equipment

Naturally some difficulty was experienced in developing satisfactory methods and equipment, but as finally employed they are briefly as follows:

A concrete box or pit was built into the road. In this was placed a contrivance similar to a hydraulic jack, the plunger of which carried a plate to receive the truck wheel. Auxiliary parts enabled the front wheel to be carried over this plate and then cleared so that the impact from the heavier rear wheel would be secured. To measure the impact, cylinders of pure copper carefully machined to exact size, ½x½ in., specially heat-treated and calibrated by submitting a certain percentage to pressure in a standard testing machine, were used. One of these cylinders was placed under the plunger of the jack, the impact of the wheel received on the plunger, and then the deformation of the copper cylinder accurately measured. Knowing the static load to give various deformations, these measurements indicated the impact load in terms of the static load.

Various Methods Employed

Evidently there are a number of ways in which truck wheels can deliver impact to a road surface, and consequently several different methods were employed to approximate some of these conditions. For example, in some instances the wheels were permitted to drop abruptly onto the plunger plate, in others obstructions were placed on the plate and run into by the wheel, and in others wedge-shaped plates were used, the wheels either being permitted to run over the wedge or to jump onto them from a take-off, thus simulating the running through or dropping into a depression with sloping sides. All of these methods were of interest and at the same time pointed out under which conditions the maximum impact was to be expected, which of course is the condition for which the design must be made. Different sizes and makes of trucks were used. The data so far, however, applies only to solid rubber tires, but the work is being continued with pneumatic and special forms of tires and wheels.

Sprung and Unsprung Loads

Before going further it may be well here to call attention to a few points concerning trucks which are well to keep in mind in further discussion of the subject and in following up the further reports of these tests.

The frame, motor, body and load of the truck rests on springs supported on the axles and is here termed a "sprung" load. The weight of the axles themselves, lower parts of the springs, the wheels and part of the drive mechanism is carried directly to the road without the intervention of springs, and is termed the "unsprung" load. When unloaded a spring has a certain neutral shape. As more and more load is applied it is deformed, becoming stressed to the amount of the load and having a tendency to come back to neutral size by the amount of this force. If the support of the wheel is removed it drops by its own weight, plus this "kick" of the spring, the load following only as the tension of the spring is relaxed. If the fall is great enough before the wheel reaches a new support, the spring may reach its full neutral shape or even expand beyond it before again picking up the load. It is in fact this action which makes the spring effective. The inertia of the falling load coming onto the spring again will compress it farther than its normal amount for that load, and there follows a rebound—in fact, a series of them, with a harmonic period and a decreasing amplitude, depending on the dimensions and make-up of the spring, unless the wheel in the meantime strikes a new depression or obstruction.

Keeping these facts in mind, it will be seen that a wheel

dropping suddenly into a shallow depression will strike with the full effect of the unsprung weight, backed by all the kick of the spring, the inertia of the sprung weight carrying it along so as to contribute comparatively little to the impact. As the depression becomes deeper the effect of the kick becomes less and of the sprung load more, as it is following the wheel down and must be picked up and supported by the springs in a short period after the wheel strikes. At some depth the effect of the unsprung weight will be neutralized by the rebound of the spring, and the impact, of course, greatly modified. At greater depths the impact will be due only to the falling of the gross load, modified by the easing action of the spring on the sprung portion. The resultant rebound of the spring will cause a series of secondary impacts of decreasing amounts at points, depending on the period of the spring and the speed of the truck. So far as I can learn, only the initial impact has been studied, and the others are probably much less.

Some of the Test Results

Turning now briefly to some of the results of the tests we find the following of especial interest:

A series of tests was run, using a Class B 3—5-ton army truck. This truck had a gross load on one rear wheel of 7,750 lbs., of which 1,837 lbs. was unsprung. Incidentally, this was a high proportion of unsprung weight. In general, the impact increased somewhat with the speed and amount of fall. The impact due to striking an obstruction running over an incline or striking an incline after a jump was much smaller than for a direct, sudden drop, and showed a proportionately somewhat greater increase with speed. For a direct drop the maximum impact was secured with a fall of 3 ins. at a speed of 15 miles per hour. The impact load in this case amounted to 42,000 lbs., or 5.4 times the static load. Since the stress in an 8-in. concrete slab for this static load is about 30 lbs. per square inch, the effect of impact is to increase this stress to about 170 lbs. per square inch, or to about one-third the ultimate strength, which apparently is something nearer the designing ratios familiar to the structural engineer than the figures mentioned earlier. Owing to the spring action, the impacts for small drops were relatively high. This truck gave a value of 28,000 lbs., or 3.6 times the static load, for a drop of only ¼ in. at a 15-mile speed. As drops of this amount are by no means uncommon, as, for example, between adjoining slabs, car track rails, etc., it is evident that this is worthy of note in our design. And it serves to show also the importance of eliminating the small depression, which is perhaps worse proportionately than the big one. It is worthy of note, however, that the impact against an incline increases with the slope, as would be expected, and consequently depressions of easy slope are less important than those more abrupt.

Another series run with a 5½-ton truck having a gross wheel load of 8,060 lbs. and an unsprung load of 1,000 lbs. showed the same characteristics of the impact as the army truck, but the impact values were materially lower, explainable only by the lower unsprung weight of the 5½-ton truck.

A series with a 1½-ton truck having a wheel load of 3,475 lbs. and an unsprung weight of 1,065 lbs., showed also the same general characteristics of impact as the heavier trucks, but, of course, considerably less in magnitude.

Effect of Unsprung Load

As a whole, the tests demonstrate conclusively that heavy motor trucks do exert an impact pressure on the road which may run several times greater than the static loads. The maximum obtained with the equipment so far was for a 5-ton army truck as given above, amounting to 42,000 lbs., with a static load of only 7,750 lbs. There are other points, however, of equal interest and perhaps of as great significance. At a 15-mile speed and with a drop of 2 ins. this truck gave an impact of 34,500 lbs., while a standard 5½-ton truck with a wheel load 310 lbs. greater, but with an unsprung load 837 lbs. less, caused an impact of only 23,500 lbs. This is a very interesting item as concerning the effect of the relative amounts of sprung and unsprung loads. The 1½-ton truck, however, under the same conditions, although having a somewhat greater unsprung load than the 5½-ton, showed an impact of only 14,000 lbs., indicating that it is not the unsprung weight alone that affects the impact. And when it is recalled that it is the load carried which gives the compression to the spring, which, in turn, increases the impact of the unsprung portion, the reason why the lighter truck shows relatively lower impact is evident.

Effect of Speed on Impact

Another point of interest is in regard to the effect of speed on impact. Usually impact has been said to vary with the square of the speed, and while the data available is not sufficient to indicate the true relation, they do quite definitely indicate that the variation is something less than the second power.

Again, the tests show that the impact does not vary directly with the drop, but is modified by the ratio of sprung and unsprung loads, making it probable that trucks of different types and build may give entirely different impacts, although carrying the same gross load on the wheels.

The application of the results of these tests may lead to some decided changes in the design of road slabs, especially those of concrete or monolithic brick. The theory of static loads indicates that the strength of a beam varies with the square of the depth. This theory has been applied in comparing different slabs for strength. It is the one used by the writer in his slab tests, and is the one used by the Illinois Highway Department in making the so-called comparative designs of different pavements. On the other hand, the theory of impact indicates that the strength of a beam varies directly with the depth. Since the action of springs, tires, etc., probably modifies the impact, it would seem probable that the true relation for strength is some function of the thickness of the slab lying between the first and second power, and it is hoped that these tests will aid in solving this part of the problem also.

Effect of Impact on Different Types of Roads

The second part of the impact tests is to determine the effect of impact on different types of roads. For this purpose sample sections of many types have been built, half of them on a dry, well-drained subgrade and half on an artificially saturated subgrade. A special impact machine to imitate the action of the rear wheel of a 7½-ton truck having a gross load of 12,000 lbs., of which 3,000 lbs. is unsprung, will be used in testing these sections. As yet

no data are available, but it will be interesting to watch for these results, for possibly some of the most far-reaching modifications in the choice and design of our pavements may develop therefrom.

Along in the early nineties the concrete pavement and the grout filler for brick were introduced. Time has developed them, and now we stand committed to these "rigid" types. But only time and study and perhaps the results of these tests, indicating the effect of impact on the various types of roads and the abilities of these various types to absorb or resist the jar and vibration, will indicate whether the rigid types will in reality carry the modern truck or whether we must swing farther along the eternal cycle and evolve elastic or resilient types to take their places.

The foregoing paper by Professor Wiley was presented at the 1920 annual convention of the Illinois Engineering Society.

FEATURES OF HIGHWAY WORK IN MISSOURI

By Alexander W. Graham, State Highway Engineer, Jefferson City, Mo.

The end of 1919 found Missouri enjoying the greatest road building movement in her history. Counties and road districts had voted $18,112,000 in bonds for the construction of state roads in each county with state and federal aid. As a result of the bond activity, the State Highway Board had approved applications for 734.67 miles of hard surfaced road, which, when completed, will cost a total of $10,226,646.34. The Bureau of Public Roads having Mr. H. H. Lotter, a resident engineer located at the state capitol at Jefferson City, to pass upon Missouri projects these applications had been rushed to Washington and 49, with a total mileage of 459.29 miles, and a total estimated cost of construction of $5,948,910.83, had been approved.

New Missouri Road Law

Missouri, except in isolated districts, had been doing little but *talk* good roads before the beginning of 1919. The close of the war found the whole country in the mood to build roads, and develop the country's resources, and the last Legislature, by passing a new road law, gave Missouri an appropriate vehicle for a great road boom. The general approval and working success of the law has been gratifying to Governor Gardner, who has been constantly pleading for good roads since he was elected and generously helping forward the present movement.

The new law authorizes the building of not less than 50 miles of state road in each county, which shall connect with the state roads in adjoining counties. On this mileage each county receives $1,200 a mile free including the cost of survey. Half the cost of building a durable road above $1,200 a mile is borne by the state and federal government, and half by the county.

The law guarantees that each county shall receive not less than $60,000 in state and federal aid on 50 miles of state road, but if a county can not build a durable road that will take care of local traffic and preserve the original investment with $1,200 a mile, and the county refuses to finance the cost above $1,200, the State Highway Department is authorized to cut the mileage and build as many miles of durable road as possible with the $60,000.

This law gave a new impetus to durable road building in Missouri. There was started a movement in almost every county in the state to vote road bonds to build the mileage authorized in each county.

The new road law went into immediate effect when Governor Gardner signed it March 17. But in spite of the fact that it took some time to acquaint the counties with its true provisions, certain portions of the public press having put forth the impression that it was a mud road law, the amazing total of $18,112,000 had been voted by the end of 1919, and petitions were in circulation asking county courts to set elections for an additional total of over $15,000,000. A majority of these elections will be set for January, February and March.

Activities of Counties

Most of the counties that have not yet done so are striving to finance their two roads and build something more substantial than $1,200 a mile roads. There have been bond failures, but the road boosters in the unsuccessful counties keep on trying, a failure merely spurring them on to greater efforts. With the bonds already voted and the proposed issues in sight, the indications are that most of the counties will have their two state roads financed early in 1920.

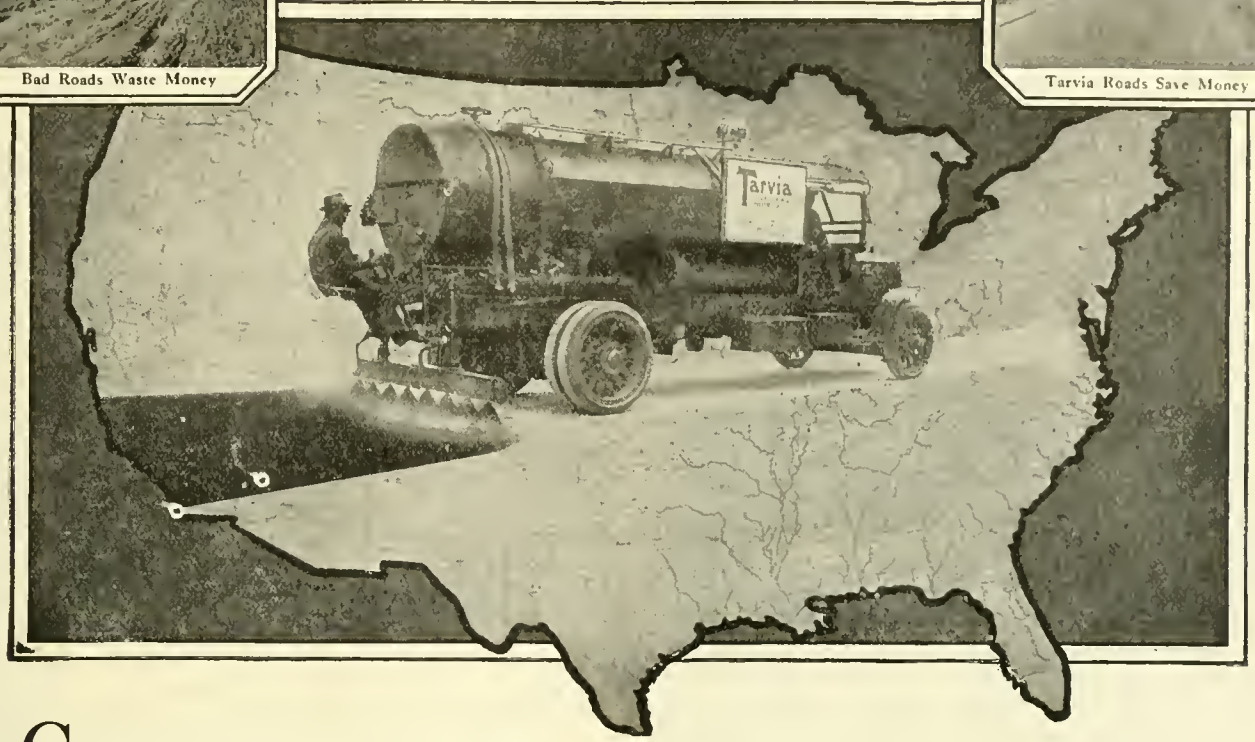
Of the $18,112,000 in road bonds voted in Missouri only about $6,500,000 was voted during 1916, 1917 and 1918, but all of that issue was tied up in the courts and not a dollar of it became available for road building until the new law was enacted. After the law went into effect it became necessary for the State Highway Department to go to the counties and subdivisions and induce them to vote bonds to provide means for launching the road programme it authorized. Pettis County took the lead, voting $500,000 June 3, and since then there has been a wide spread movement in the state to provide funds to meet the requirements of the new law. And the splendid record of the Department to date has been made in the face of organized opposition in different sections of the state.

During 1917, 1918 and 1919 Missouri completed 480 miles of road with state, federal and county aid. Of this mileage 90.8 was of gravel, 25.6 of macadam, 7.9 of chats, 7.8 of bituminous macadam, 2 of asphaltic concrete, 2.7 of Warrenite, 6.5 of concrete and 336.7 of graded earth. The earth road was constructed prior to the passage of the new law. The total cost of this work, which includes bridges and culverts, was $1,106,600.

Many Contracts to be Let

Many contracts have been let and many more will be let shortly, the work to start this spring, for the construction of the projects approved under the new road law. Work is now under way on 97.25 miles of road and ready to begin on 21.72 miles more when the weather permits, distributed as follows: 7.65 miles of gravel and macadam in Callaway County; 13.5 miles of concrete in Jasper County; 3 miles of bituminous macadam in Boone County; 6.5 miles of chats in Vernon County; 26 miles of gravel in Cole County; 15.5 miles of concrete in Mississippi County; 27.5 miles of gravel in Scott County; 2.2 miles of asphaltic concrete in Buchanan County; 19 miles

Put your town on the good roads map this year



COME to think of it, is there anything so expensive to a community as *bad roads?*

Bad roads slow up business, lower land values, make markets inaccessible, isolate neighbors, cost a lot of money and waste much more.

People tolerate bad roads year after year because they *think* good roads cost too much.

But good roads *are not* expensive, if they are built in accordance with a well-thought-out program, somewhat along these lines.

Consider—

1. The traffic the road will have—
2. Its initial cost—
3. Cost of maintenance—
4. Durability—
5. Ease and rapidity of construction—
6. What "Barrett Service" can do for you.

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of concrete in New Madrid County; 5.3 miles of bituminous macadam in Pettis County; 13.07 miles of bituminous macadam in Clay County; 1.76 miles of brick in Randolph County and 1.6 miles of bituminous macadam in St. Charles County. The total estimated cost for the construction of this mileage is placed at $1,108,824.71.

More miles of state and federal aid roads would have been under construction during 1919 if contractors had bid more freely upon advertised projects. The new road law requires competitive bidding, and when no bids are received within the estimate, the State Highway Department is authorized to complete the project by private contract, force account or otherwise, provided it can be done within the estimate.

Failing to receive any bids, the Department was forced to enter into a contract with the State Prison Board for the building of 7.65 miles of gravel and macadam in Callaway County with convict labor, and the scarcity of contractors and the great number of projects to be let this year will force the Department to build other roads with convicts. About the only projects which atract road building contractors call for expensive concrete, brick and macadam roads. Counties preparing to build the less expensive roads will be forced to organize local contracting concerns, and that is now being done in many counties, in order to build this year the many roads that have been approved.

The roads to be built in Missouri this year with state and federal aid will be almost entirely of a hard surfaced type. Of this mileage embraced in the applications that have been approved by the State Highway Board, contracts for the construction of which this year will be let shortly, 475.16 miles are to be of gravel to be constructed at a total estimated cost of $3,299,147.53; 100.95 miles of concrete at $3,461,452.01; 80.144 of bituminous macadam at $1,959,263.64; 8.241 miles of macadam at $62,043.41; 19 miles of water bound macadam at $170,869.88; 8 miles of asphalt at $142,053.45; 6.54 miles of Joplin chats at $41,514.00; 19.42 miles of brick at $847,338.63; 17.22 miles of graded earth at $242,973.00.

Road Surveys

The new road law authorized the designation of 6,000 miles of state road in Missouri and directed State Highway Engineer Graham without delay to survey and make plans of this mileage. It fixed the cost of the surveying and plans at not over $100 per mile on the average, the cost to be deducted from the $1,200 a mile which each county was to receive free on not less than 50 miles of state road.

The engineering department promptly placed six state surveying parties in the field, made contracts with private engineering firms and gave permission to counties desiring to do their own surveying for about 2250 miles of road. By Dec. 1, 1919, when freezing weather forced the suspension of work in the field, one-third of the 6,000 miles had been surveyed. Six hundred miles of this work had been done by the state parties. If the present rate of surveying can be continued all of the authorized mileage will be done by the end of 1920.

Surveys have been made in whole or in part in 86 counties. In the remaining 26 counties no start has been made, but work in them will begin as soon as the weather permits in the spring.

The surveying by the six survey parties has been done at an average cost of about $75.00 a mile, leaving $25.00 a mile for the completion of the plans. The balance of the surveying by the counties and contracts with private engineering concerns has been done at the price authorized by law and what the county agrees to pay in addition, and that includes the plans.

This year promises to surpass 1919, in road building as far as 1919 surpassed previous years. The State Highway Board, at its meeting Jan. 13, 1920, started the new year by breaking all previous records in approving applications for the construction of state highways with state and federal aid. Sixteen projects, calling for the construction of 157.61 miles of state road at a total estimated cost of $2,943,692.18, were approved. This brings the total mileage of state and federal roads approved to date up to 853.48 miles, which will cost a grand total when completed of $11,297,910.29.

There is nothing speculative in the $11,297,910.29 worth of road work that has been approved to date. It represents the real road building situation in Missouri, for the State Highway Board has not approved an application for state and federal aid until it positively knew that the county, subdivision or interested parties making the application had provided its part of the money to build the road.

CONSERVING POLES AND POSTS

Timber suitable for telegraph and telephone poles, fence posts, etc., is becoming scarce and expensive. It is estimated by the Forest Service that 60 years hence will witness the practical extinction of such material. At present about 4,000,000 poles are being erected annually. Records compiled by the Forest Service show that 95 percent of all poles are destroyed by decay, 4 percent by insects and the remaining 1 percent by mechanical abrasion.

Scientists who have been giving the subject attention advise, as a result of experiments conducted by them, that creosote treatment applied to the ends of the poles and posts imbedded in the ground will lengthen the life of the poles as per the following tabulation:

White cedar ..16 years (untreated) to 30 years (treated)
Cypress .....6 years (untreated) to 15 years (treated)
Chestnut ....12 years (untreated) to 16 years (treated)
Pine .....6½ years (untreated) to 20 years (treated)
Juniper .....8 years (untreated) to 18 years (treated)

There are three methods of treatment adaptable to the purpose: The open tank method, whereby only the butts of the poles are treated; the pressure process, used only on short poles, and the brush method, which may be applied in the field as the poles are being set. The employment of the open tank method calls for the application of the treatment before the poles are shipped on the job.

As creosote and the labor required to apply it are much cheaper than new timber, it is needless to say that railroad companies, telegraph and telephone companies, farmers and all others using large quantities of timber for poles and posts are giving this matter much serious consideration. Even yet, however, entirely too many posts are being set untreated and unprotected. This is a form of business extravagance that is unwarranted.

WATER WORKS SECTION

TWIN FALLS, IDAHO, WATER SUPPLY AND PURIFICATION PLANT

By Robert E. McDonnell, of Burns & McDonnell, Consulting Engineers, Interstate Bldg., Kansas City, Mo.

About ten years ago upon the site where Twin Falls, Idaho, now stands there was nothing more than a barren sage brush waste; therefore, water for irrigation and domestic needs has played an important part in the upbuilding of this modern city, which now has about 10,000 population.

Water Supply

In providing water for irrigating the farms, the city also is provided through the same canal water for its domestic needs and fire protection. The water supply is from the Snake river, taken from a canal which is located about 2½ miles south of Twin Falls. From this canal the water for municipal use flows through a 24-in. pipe line, passing through a Venturi meter and also through a float valve, which automatically regulates the elevation of the water in the receiving basins.

The water supply for Twin Falls, as in all other western cities, must be an adequate volume for garden irrigation, lawns, and an unusually large amount for domestic requirements because of the very dry summer seasons. This necessitates procuring three to four times as much water per capita as the average municipality uses throughout the eastern states. The total capacity of the plant is therefore planned for 6,000,000 gals. per day and the water consumption during certain hours of the day has already reached this large volume.

A Typical Western Case

Many cities through Idaho, Washington, Oregon, Utah, Montana and other western states procure their water supply from irrigating canals similar to Twin Falls and these cities using such source of supply have found the canal water so contaminated as to be unsafe to drink without purification. This contamination usually arises because of drainage into the irrigating canals from farmhouses and from discharging of raw sewage without treatment into the streams. The conditions in Twin Falls are therefore quite similar to those in many other of the western municipalities, and the successful handling of this same problem at Twin Falls may be of interest and helpful to the municipalities of many other western states that must sooner or later solve this same question of providing an absolutely safe water for domestic and commercial needs.

Filter Plant

At Twin Falls the canal supply is at sufficient elevation above the city to permit of a gravity plant; the water flows from the canal through a 24-in. pipe line, measured with a Venturi meter into a receiving basin. The level of the water in the receiving basin is regulated by an automatic float valve which maintains a constant elevation over the filter. The canal at Twin Falls, as is usual with canals, must be emptied at certain seasons of the year for repairs, and at times the water in the canal is low, and to provide for this emergency low service pumps are utilized for lifting the water from the canal at these low stages into the settling basins. A large settling basin of approximately 20,000,000 gals. capacity has been provided for storage of water during times of repair. The filtration system is no different than other purification plants that have been described quite fully in engineering periodicals,

MACHINES FOR DRY-FEEDING SULPHATE OF ALUMINA, TWIN FALLS, IDAHO, WATER PURIFICATION PLANT.

except that advantage has been taken in this plant of all of the modern improvements and methods utilized in handling of the water.

Sulphate of alumina is used as a coagulate and this is fed through dry feed machines in a pulverized condition, feeding through a hopper and delivered to the water as a ribbon of chemicals over a small wheel. In order to insure a thorough mixing of the sulphate, baffle walls are so arranged as to give the water a travel of 1,600 ft., passing up and down through these baffle walls. After this thorough mixing the water passes to two concrete lined settling basins, where approximately 85 percent of the sediments and impurities are removed from the water. After the settling basin treatment the water passes over a weir to a concrete flume, flowing on to the sand filters. Six of these sand filters are provided, with a normal capacity of 1,000,000 gals. each, making a total of 6,000,000 gals. per 24 hours. Each of these filters is provided with marble top operating tables with hydraulically operated

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EXTERIOR VIEW OF TWIN FALLS, IDAHO, WATER PURIFICATION PLANT. FILTER HOUSE IN FRONT, HEAD AND CHEMICAL HOUSE IN REAR.

valves, and water from each filter passing through a Venturi meter with a recording equipment, so that the rate of each filter can be easily observed.. On the operating table each filter also has a control stand so arranged as to indicate the time when the filter requires washing, which will be shown by the loss of head of each filter recorded on the operating table. The washing of the filters is accomplished with a wash meter pump of large capacity. The plant is provided with a master controller which forces the plant to operate in proportion to the demand of the city, which is one of the latest improvements in purification equipment and is very desirable from a standpoint of an economical operation.

A Modern Plant

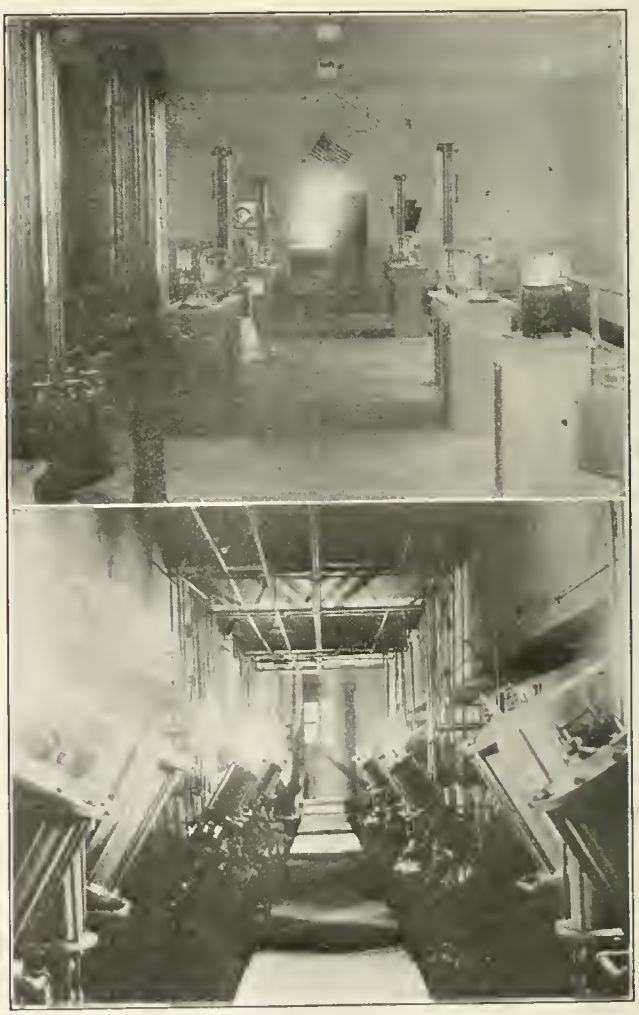
Nothing has been left undone to make the Twin Falls purification plant the most modern plant in the United States. The purification plant delivers the water to the city free from turbidity, odor, color, and tests made show an average of 98% of all bacteria removed. The design of the purification works, both interior and exterior have been of a character that is pleasing to the eye and makes the entire plant one of the show places of the municipality. The water after purification flows to the city by gravity through a line 2½ miles long and 24 ins. in diameter. This gravity flow line is of California redwood pipe, the line being built of continuous stave pipe assembled in the trench. The purification plant is on a hill 190 feet above the city and is delivered to the municipality at a pressure in the mains throughout the business district of 70 lbs. per square inch.

Cost

For the building of the purification plant and improvements in the distribution system, Twin Falls voted a bond issue of $375,000. While this bond issue may seem high for a city of 10,000, yet it is less than one-half the amount of an estimated cost of a former gravity supply which had been considered, but for which the voters failed to ratify a bond issue. The entire purification plant, settling basins, and pumping equipment is so arranged that additional units may be added as the growth of the city justifies an increase in capacity.

Meterage

Before the plant was turned over to the city the Consulting Engineers, Burns & McDonnell, Kansas City, Mo., through their resident engineer, C. E. Painter, made an investigation of the meter situation, with a view of recommending the complete meterization of the entire city. The result of this investigation showed only 38 meters out of 1800 taps and the City Commissioners immediately ordered 500 meters and a price contract was made for future orders and within a short time Twin Falls will be 100% metered. This report of the engineers showed that the present purification plant would have to be extended and enlarged within five years unless prompt action was taken toward curtailing the unnecessary waste of water. Between 11.00 A. M. and 1:00 P. M. and from 5:00 to 7:00 P. M. water in Twin Falls was used at the rate of 7,000,000 gal. per day. It will, therefore, be seen that the plant had to run in excess of its normal 6,000,000 gal. capacity during these peak load hours, but with the restriction on the waste of water the present capacity of the plant should be sufficient for 15 to 20 years. An investigation was made of 24 customers using water on a flat rate. Leaky plumbing was found responsible for the largest loss in these 24 hours and meters were installed on these 24 users and a later investigation was made to determine the result and it was discovered that $196 was the revenue produced under the flat rate, while under the yearly rate with meters a revenue of $303.88 was produced and of these 24 customers 50% were being overcharged and the other 50% were being presented water free of charge. This was, of course, not equitable or just. The total income was increased 55% and much water was saved to the municipality. The City Council and the Mayor co-operated with



INTERIOR VIEWS OF WATER PURIFICATION PLANT AT TWIN FALLS, IDAHO.

UPPER VIEW: OPERATING FLOOR. LOWER VIEW: FILTER GALLERY.

the Consulting Engineers in carrying out the recommendations and at Twin Falls, as it should be in other municipalities, it was felt unwise to operate a modern water purification system and then permit the water to be wasted through illegitimate use.

The entire water system at Twin Falls was designed and supervised by Burns and McDonnell, Consulting Engineers, with C. E. Painter as their resident engineer. The general construction contract was awarded to Heuser-Packard Construction Co. and a local contractor, Mr. Haskins laid the mains and distribution system. The filtration plant was erected by the Pittsburgh Filter and Eng. Co. of Oil City, Pennsylvania.

The accompanying cuts illustrate some special features of the plant. It frequently happens that municipalities will procure a model purification plant and then leave the operation to an inexperienced person and poor results will often follow. However, at Twin Falls the city officials procured a trained filter operator in J. E. Byers, who has recently returned from the army service, and under his operation the purification plant receives constant attention, daily analysis of water and the consumers are assured of uniform results with a minimum amount of chemicals and safe water free from dangerous bacteria.

ELECTRICALLY OPERATED WATER WORKS PUMPING PLANTS IN INDIANA

By G. C. Blalock, Instructor in Electrical Engineering at Purdue University, Lafayette, Ind.

According to available records, there are 206 public water works systems in the State of Indiana. Seventy-six of these, more than one-third, are operated partially or wholly by electricity. During the past winter and spring, 27 of these plants were visited by members of the Engineering Experiment Station staff of Purdue University with a view to ascertaining the present status of electrical operation of such plants. The results of this investigation, with other pertinent data, will appear shortly in the form of a bulletin issued by the Experiment Station.

Observed Conditions

The plants visited supply water to communities ranging in population from 500 to 25,000 and were found to be operating under a variety of conditions.

Fifteen plants used some form of elevated storage—tank, standpipe or reservoir; six were provided with compression tanks, the pressure being automatically controlled by pressure gage relays, while the remaining six had no provision for storage, but maintained direct pressure by continuous operation of the pumps. This probably represents in a general way the distribution as to types of plants over the state as a whole.

About 20 percent of the plants visited made use of deep well pumps—air lift or displacement. The remainder used surface pumps, though in many cases the pumps were placed in pits from 4 to 15 ft. below ground level in order to reduce the suction lift.

Drilled Wells

The most commonly encountered source of water supply was the drilled well, 6 to 10 ins. in diameter and from 100 to 300 ft. in depth. In a few cases the supply came from streams or spring-fed reservoirs, but these were rather exceptional. The water from wells appears to be,

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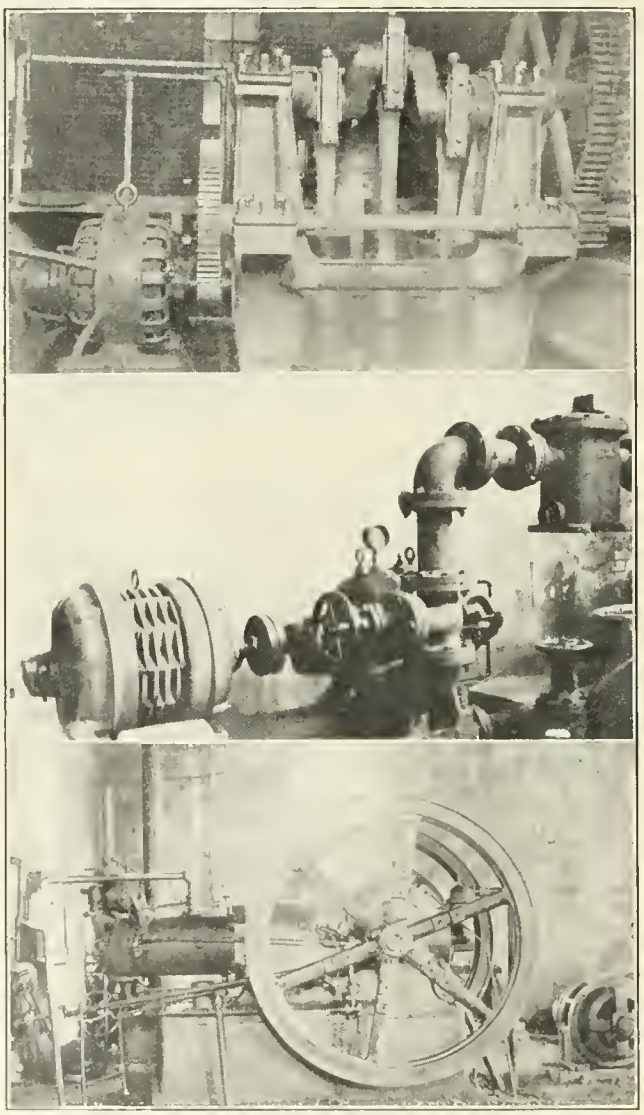
in general, clear and pure, requiring no outlay for purification equipment. In most localities the water stands from 10 to 20 ft. below ground level, but in a few places the water flows to the pump under sufficient head to eliminate entirely the necessity for priming.

Types of Pumps

Centrifugal pumps and triplex displacement pumps were encountered in about equal numbers and the plant which contained neither of these types was exceptional.



ELECTRICALLY OPERATED PUMPING PLANTS IN INDIANA.

Top View: Goulds Triplex Pumping Unit at Plymouth. Motor Westinghouse 15-h.p., type HF. Elevated tank storage, manual control.

Center View: Domestic service set and water meter at North Manchester; 25-h.p. Motor Westinghouse, type CS, two-stage Alberger pump, 380-g.p.m., 160-ft. head. Automatic operation standpipe storage.

Bottom View: The 20-h.p. General Electric, type KT motor and oil engine it replaced at Williamsport.

One rotary pump was observed, handling the second stage of a 2-stage system, and the city of Lafayette has three direct-connected motor-driven propeller pumps forming the first stage of a 2-stage system, the second being handled by steam pumps. These, however, are held for emergency use, the first stage pumping being normally done by air lift. Also, in one case the first stage was handled by motor-driven deep-well pumps and the second stage by steam pumps. In 75 percent of the plants inspected, however, the single stage system was used.

Alternating Current Used

Alternating current energy was utilized in practically all cases, either because direct current was not available or because the alternating current motor is cheaper, more rugged and requires less attention. Various types of alternating current motors were found to be in use, the choice depending chiefly upon type of pump to be driven. In most cases the available energy supply is 60-cycle, 3-phase current, and the choice lies between the squirrel cage and the wound rotor types of induction motor, the former being used for driving centrifugal pumps, where the starting load is light, and the latter for driving displacement pumps, where the starting load is relatively heavy. Exceptions were noted to this general rule, and in one case synchronous motors were found giving very satisfactory service. Single phase, 25-cycle motors were encountered in one plant, the energy being obtained from an interurban railway transmission line which passed through the town.

Water Pressures

The pressures in use for domestic service were found to range from 25 to 90 lbs. per sq. in., the average being about 40 lbs., corresponding to a head of 92 ft. In many cases provision is made for raising this pressure for fire-fighting purposes to 90 or 100 lbs., by cutting off the storage and bringing a special high-pressure unit into service. It is not uncommon to find steam pumps used for securing the extra pressure needed for fire service, though the motor-driven fire service pump is popular in localities where auxiliary steam equipment would be expensive to provide and maintain. There appears to be a growing sentiment in favor of securing the extra pressure by using a portable pump at the location of the fire, rather than by boosting the pressure over the whole system, thereby making both mains and plumbing liable to damage or even complete failure at a time when such failure would be most serious. This method also eliminates the extra demand for water at service connections during the high pressure periods when the greatest possible supply should be available for fighting fire.

Pump Capacities

The average pump capacity provided for domestic service appears to be about 200 gals. per minute per 1,000 population, but this figure is not of very great value, since the capacity required depends very largely upon local conditions and may vary widely for towns of the same population. Also, the system used has considerable influence upon the pump rating. A direct-pressure system must have sufficient capacity to supply the peak of the load, while in a storage system the pump needs to supply only the average demand, anything above this being drawn from the storage. The tendency is to provide too much rather than too little capacity, in order to be on the safe side and to provide for future requirements. The pumping units designed for special fire service average about 250 gals. per minute pump capacity per 1,000 population. These units also provide reserve capacity for abnormal demands other than for fire service.

Reported Conditions

Town officials and operating men expressed themselves almost unanimously as well pleased with the results obtained through use of electrically operated equip-

ment. Appreciation of the greater convenience and decreased operating expenses was especially marked in places where the pumps were previously steam driven. One plant was visited in which steam operation had been resumed after a trial of electric operation, but no one available at the time could give an adequate reason for the dissatisfaction with the electric drive.

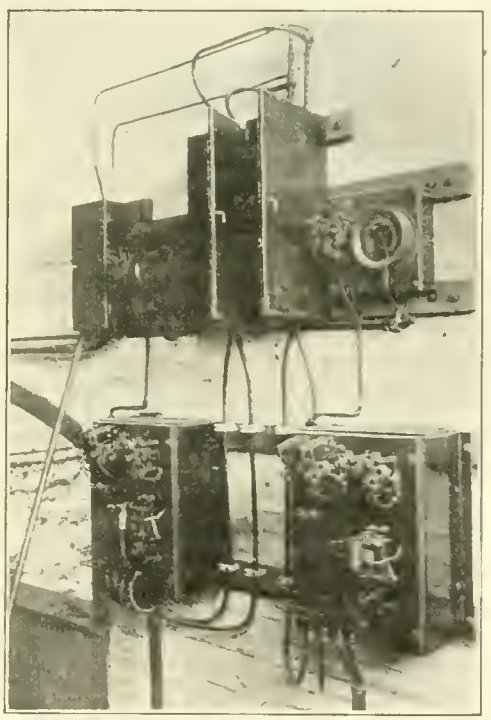
Another case of dissatisfaction was encountered where a direct-connected, motor-driven centrifugal pump was giving unsatisfactory service, though no blame was placed upon the motor itself. The pump was obviously not designed for the conditions under which it was working and the result was an energy consumption very greatly out of proportion to the work done. Plans were being made to replace the centrifugal with a triplex pump, though it appears likely that a change in impellers would have accomplished the same result. This serves to emphasize the necessity for using great care in specifying a centrifugal pump for a given application, in order that its characteristics may be suited to the work it is expected to do.

Minor Troubles with Equipment

Numerous cases of minor troubles with the equipment were reported. Of those directly chargeable to electric operation the only ones of serious import were those due to lack of adequate protective devices between motor and line. Some of these involved no serious consequences, while others involved considerable expense and inconvenience, as well as fire risk. It would appear that the necessity for adequate protection of the motor and control circuits is not generally appreciated. The cost of such protective apparatus is not great and will soon be repaid through decreased repair bills and greater reliability of the equipment. Troubles were reported due to lack of reliable low voltage and no-voltage cut-outs, and also to lack of proper protection against lightning. Good lightning-arrester equipment, properly installed, is absolutely essential where power is secured from a transmission line, and is the only means of preventing damage from this source, which may vary all the way from a breakdown of insulation in one or more coils to destruction of the entire electrical equipment.

Next to having the apparatus itself it is of importance that attendants should understand the significance of the protective devices. One plant was visited where no voltage protection was provided, but a former attendant had decided that by wedging the starting handle in the full-on position he could start the pump from the power station and save himself a half-mile walk. Unfortunately, the motor windings did not survive the initial experiment, but had to be entirely replaced.

The most frequent source of trouble other than electrical appeared to be due to freezing in severe winter weather. Bursting of pump cylinders was reported in numerous instances. In some cases these breaks had been repaired by welding, in others the cylinder had to be replaced. Troubles from this source can be charged only to neglect in providing some means of keeping the temperature sufficiently high to prevent freezing.



PRESSURE GAUGE RELAYS AND AUTOMATIC CONTROLLERS FOR TWO SINGLE PHASE 15-H.P., 25-CYCLE MOTORS DRIVING TRIPLEX PUMPS AT NEW CARLISLE, IND.

Cheap Equipment Causes Trouble

The installation of cheap equipment invariably results in troubles due to excessive wear and breakage, and poor judgment in the selection and use of equipment augments the difficulties along this line. In one plant the first stage was handled by an air lift and the second by a cheap rotary pump. The latter was driven at such high speed that it handled water faster than the air lift could supply it, so a portion was by-passed and pumped over again. In

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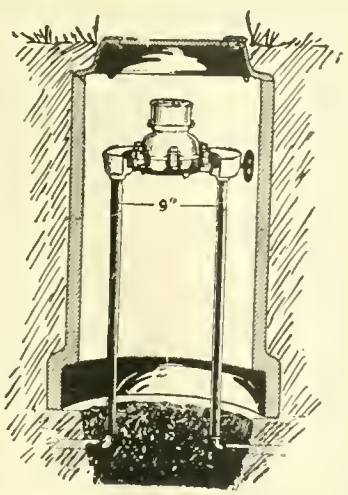

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addition, the wear on the impeller was so great as to necessitate its renewal two or three times each year.

Troubles due to flooding sometimes occur in plants having the pumps located in pits. Unless the motor windings have been thoroughly water-proofed they are sure to be more or less permanently damaged, with consequent shortening of their useful life, although the damage may not be such as to require immediate rewinding.

Improper alignment of pump and motor causes undue wear and results in decreased efficiency and increased maintenance cost. The same cause sometimes results in broken rods in case of deep-well pumps.

Corrosion and rapid wear due to sediment in the water being pumped were reported in one or two instances.

Meterage

The practice of selling water by meter appears to be rapidly superseding the old flat rate system. Of more than 13,000 service connections reported, nearly one-third were metered. Four systems were entirely metered, while only two had no meters at all. Many towns are changing over to the meter system as rapidly as circumstances permit, and expect to have all connections metered within a year or two.

Only six of the towns visited had provision for metering the pump discharge, despite the obvious advantage of having this means of checking the performance of the pump and motor. With a watt-hour meter on the input side of the unit and water meter and pressure gage on the output side, the duty and over-all efficiency may readily be determined at any time and any marked drop detected and accounted for. A centrifugal pump needs particularly to have its performance checked to avoid the marked drop in efficiency which occurs when the impeller is not properly designed for the conditions under which it is working. The substitution of an impeller of slightly different design may effect a saving which will pay for both meter and impeller within a comparatively short time.

Operating Records

It was found rather difficult to obtain accurate records of plant operation and costs, particularly in the smaller towns. Combined power and pumping plants frequently do not provide separate meters for measuring the energy supplied to the pump motors nor divide the operating costs equitably between the power and pumping departments of the plant. Where energy is obtained from sources not owned or controlled by the interests operating the pumping plant, the meter provided often includes the energy used for street lighting, station lighting and heating or other purposes, and, as previously mentioned, it is not often that provision is made for measuring and recording the amount of water pumped. The data obtained therefore involves estimates in many cases, and should be considered as indicating plant performance in a general way only.

Data for calculating energy consumption per 1,000 gals. of water pumped was obtained for 14 towns. In kilowatt-hour per 1,000 gals. this energy consumption ranged from a minimum of 0.20 to a maximum of 3.28, giving an average value for the 14 towns of 1.31.

Since there is considerable variation in the total head against which these pumps are working, a better measure of performance may be obtained by reducing the figure given for each plant to a basis of 100 ft. total head. This gives values ranging from 0.125 to 1.96, with an average of 0.90 kw.-hr. per 1,000 gals. per 100 ft. head.

The operating cost per 1,000 gals. was found to range between 0.88 and 16.83 cts., with an average value of 4.97 cts. Reduced to a basis of 100 ft. head, this average becomes 3.74 cts. per 1,000 gals. per 100 ft. head.

Tests

Two plants equipped with meters for measuring the pump discharge were selected, and tests were run, with two objects in view: First, to determine the duty and over-all efficiency of the pumping unit, thus obtaining a basis for figuring energy costs per unit discharge; and second, to determine the nature of the power demand and thereby establish the degree of desirability of pumping loads from the central station point of view. The test in each case extended over a period of 24 hours, and in addition to kilowatt-hour and water meters, a graphic recording wattmeter was used for measuring and recording the power demand.

The unit tested in the first plant consisted of a 2½-in., single stage, 175-gal. per minute, centrifugal pump, driven by a 15-h.p., squirrel-cage type, induction motor, pumping continuously against the direct pressure of the mains. A total pumpage of 11,900 cu. ft. was observed—an average rate of 61.8 gals. per minute—against a pressure of 40 lbs. per sq. in., with input of 9.38 h.p., giving an over-all efficiency of 16.7 percent. Estimates based upon pipe friction tables give about 10 ft. loss of head in elbows, valves, meter, etc., between the pump intake and the point at which the pressure gage was attached to the main. Including this loss of head raises the efficiency about 2 percent. This still gives a very low over-all efficiency, but it should be noted that the pump is discharging but little more than one-third its rated capacity, this resulting in the motor running at considerably less than its normal rating. Neither pump nor motor can therefore be expected to show very good efficiency. It is evident that this unit is not operating under the conditions for which it was designed, resulting in high energy consumption per unit output.

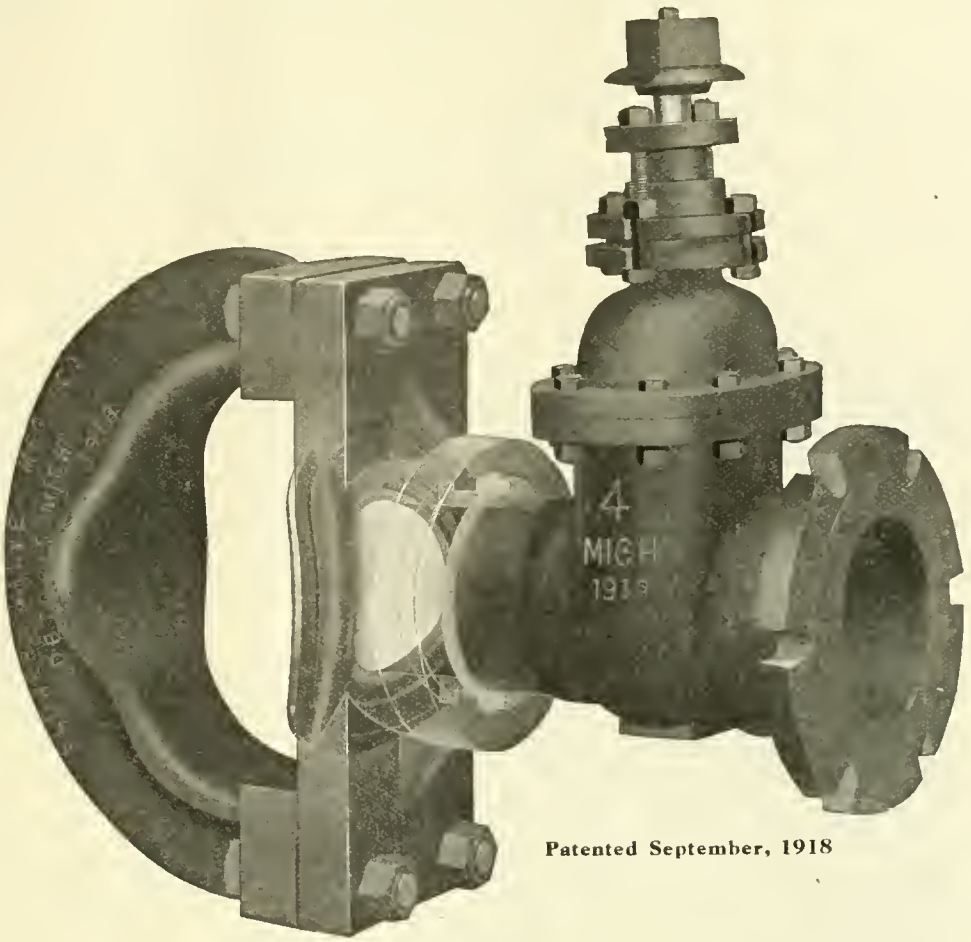
The unit tested in the second plant consisted of a 4-in., 2-stage, 380-gal. per minute, centrifugal pump, driven by a 25-h.p., squirrel-cage type, induction motor, pumping to mains, with standpipe storage, the frequency and duration of pumping periods being regulated by a pressure-gage relay and an automatic motor starter.

Three runs of approximately two hours each, at an average pressure of 55 lbs. per sq. in., gave a pumping rate of 350 gals. per minute, with an input of 32.25 h.p., showing an over-all efficiency of 38 percent. Estimated loss in head due to friction amounts, in this case, to about 35 ft., and inclusion of this loss as part of the total head raises the efficiency about 10 percent. The over-all efficiency in this case checks closely with manufacturers' estimates for this size and type of unit, and the unit is evidently well adapted to its work.

Conclusions

The conclusions arrived at as a result of investigation and study of the present status of electrically-operated pumping plants of Indiana may be summed up as follows:

1. Where local conditions have been carefully considered, the type and capacity of pump and motor which best suits those conditions intelligently selected, electric-



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Costs are high. Every possible economy should be exercised.

The improved Flower sleeve will do much to save labor and speed up work, Less digging, less caulking, no pouring of lead—all these mean lower costs.

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ally-driven pumps have proven highly satisfactory; they have been found to be easily handled, convenient, reliable and economical.

2. While the motor itself is very unlikely to give trouble, and transmission lines have proven quite reliable, yet it appears advisable to provide some auxiliary source of power. The automobile-type gasoline engine appears particularly well suited to this purpose.

3. The energy consumption in properly designed plants may be expected to vary from 0.2 to 2.0 kilowatt-hours per 1,000 gals. per 100 ft. head, with 1.0 as a fair average.

4. The operating expenses for an electrically-operated plant are low—considerably below those for a steam plant and appreciably below those for an internal combustion engine plant.

5. The pumping plant load is a desirable one from the central power station point of view.

The foregoing paper by Mr. Blalock was presented before the annual convention of the Indiana Engineering Society, January 24, 1920.

DESIGN AND COST OF WATER SUPPLY DAMS AT JACKSONVILLE AND DECATUR, ILL.

By Samuel A. Greeley, Consulting Engineer, 39 West Adams St., Chicago, Ill.

The Jacksonville Dam

Jacksonville, one of the oldest cities in Illinois, has been contending with the water supply problem during nearly its entire existence; in fact, its difficulties in securing an adequate supply have been so often repeated that only a brief mention of them need be made here.

Originally a small impounding reservoir supplied the town, supplemented shortly after by another small reservoir formed by a low dam across the stream, from which the future supply is to be drawn. These two sources later proved insufficient and other means were sought from time to time. Wells in the Illinois river bottom lands did not prove a success, and finally some drift wells were sunk north of the town. The water from these wells, with the other sources, form the present supply. The quantity is inadequate and the quality unsatisfactory.

The present population is about 16,000, and, in addition, there are several public institutions which bring the total population up to about 19,000. The city is fully metered and has an average daily consumption of about 1.25 million gallons per days. The maximum demands are modified by a storage reservoir holding a day's supply and located high enough to provide a gravity supply.

Jacksonville Impounding Reservoir

Upon investigation, several possible sources of supply were apparent: impounding reservoirs on any one of four streams in the vicinity and enlarging the present well system. All factors considered, it was finally recommended that a new impounding reservoir be formed by constructing a dam across the south fork of the Mauvaiseterre creek, adjacent to the old pumping station. The total tributary area is about 27 sq. mi., 2½ sq. mi. of which supplies a small reservoir incorporated in a park.

The new reservoir will have a maximum depth of 14 ft. to the spillway, flood approximately 240 acres with water at the crest elevation, and contain about 430,000,000 gals. The available draft will average 1,500,000 gals. per day and 2,000,000 gals. per day in all but the very dryest years.

Should future demands require more water, additional storage may be obtained upstream or an impounded supply from an adjacent watershed may be devoloped and pumped over a low divide.

Design of Jacksonville Dam

The city voted a bond issue to finance the project in accordance with the recommendations. The length along the crest of the earth section is about 600 ft. and the height is 22 ft. The spillway is 160 ft. long and is set 8 ft, below the top of the earth embankment. Provision for a flood flow of 4,500 sec. ft., with a 4-ft. flow over the spillway, is made, which is equivalent to 167 sec. ft. per square mile. The spillway is practically a submerged weir with discharge into a sloping channel. The channel is narrowed to 65 ft. wide at the lower end, thereby using up a portion of the velocity head, and is lined with 6 ins. of concrete on gravel to prevent erosion from the high velocities.

Bids were taken in April, 1919, and a contract for $58,887 awarded to John T. Walbridge Engineering and Contracting Company, of Chicago.

The material in the dam is compacted clay taken from excavation in the side hill, which excavation forms the spillway channel. A concrete conduit and gate house are located near the center of the earth embankment. The concrete conduit was used to take care of the ordinary stream flow during construction and is to carry the pipe lines to the pumping station. There were no floods to speak of and the work was carried through with practically no delay. The dam is now finished and water stands within about 4 ft. of the spillway. Bids for a filter plant will be taken in a few weeks.

Cost of Jacksonville Dam

The final costs on the dam are as follows:

1.	Earth fill, 28,453 cu. yd. at $0.50	$14,226.50
2.	Stripping 3,104 sq. yd. at $0.60	1,862.52
3.	Excess spillway excavation, 3,517 cu. yd. at $0.40	1,406.80
4.	Core wall, 1,666 cu. yd. at $2	3,331.80
5.	Conduit and gate house	9,300.00
6.	Slope paving, 4,000 sq. yd. at $2.50, 1,123 sq. yd. at $2	7,754.00
7.	Spillway, $21,000, less 5,313 cu. yd. at $9	16,218.30
		$54,099.92

Cost per million gallons of storage capacity equals $12,560.

The Decatur Dam

In Decatur the need for additional water supply has been recognized for the last 8 or 10 years. The extreme dry weather flow of the Sangamon river there is almost nothing. The problem was to remedy this condition by the construction of a storage reservoir.

Preliminary investigations and action by the city council had settled the location of the proposed dam. The storage required, the type of dam and spillway capacity were items requiring extensive study.

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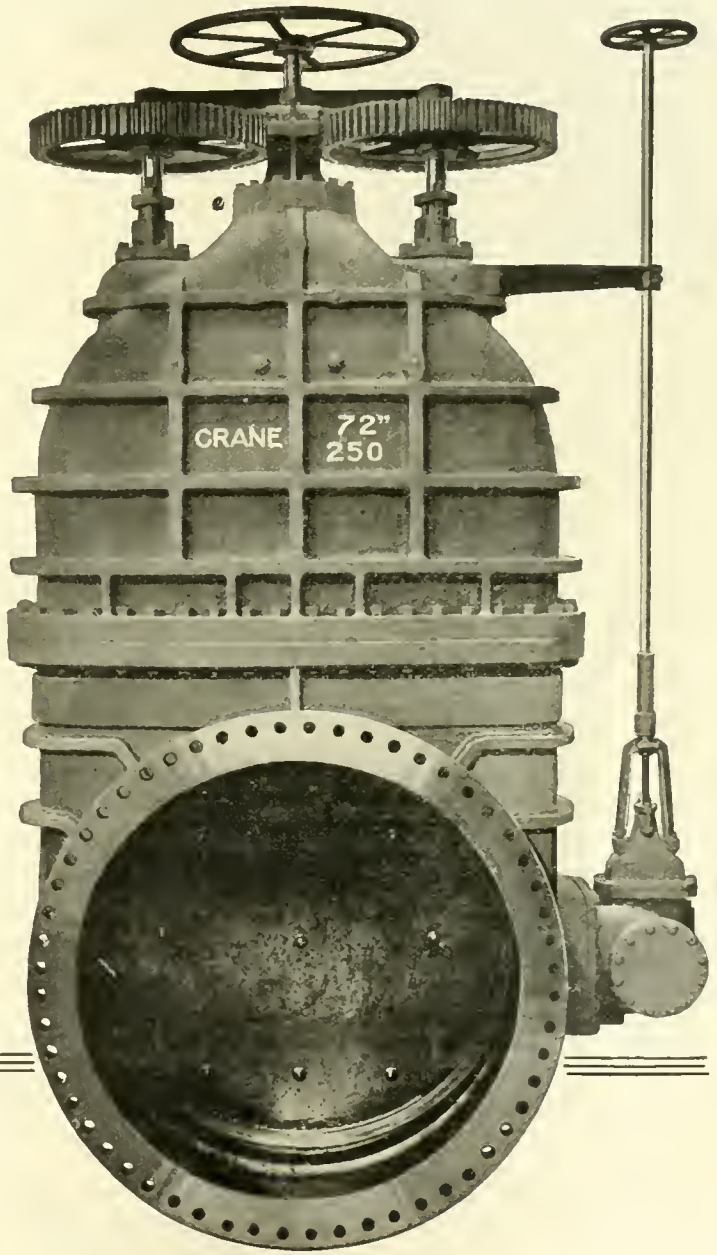
The massive construction of the valve makes this high working pressure possible with a large factor of safety.

This valve has two bronze spindles, upon which the huge gates (weighing 4½ tons) may be readily raised and lowered by the 42-inch hand wheel, operating in connection with the gears. The gates are bronze-faced and travel on bronze rollers on bronze tracks in the valve body.



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A thorough investigation of the entire problem was made and a considerable amount of field work done. All of the available data on flood flows in Illinois and the surrounding states were examined. The maximum flood on record in the Sangamon river at Decatur occurred in 1913 and was found to be approximately 21,500 sec. ft., equivalent to 25 sec. ft. per sq. mi. from the tributary area of 862 sq. mi. Assuming a 5-ft. depth overflow, a spillway 500 ft. long would be required. The earth embankments will be 13 ft. above the crest, so that the spillway will safely pass a considerably greater flood.

The amount of storage required was determined from local conditions, which made it feasible to provide a total storage of about 9,000,000,000 gals., yielding an average daily flow of about 40,000,000 gals. per day.

Design Features of Decatur Dam

Various types of sections for the spillway were studied, and it was finally decided to adopt a concrete gravity section. Borings indicate a reddish brown clay for the first 10 ft., with alternating layers of gravel and sand for 10 to 40 ft. Below this is an 8-ft. layer of clay, and below this more sand.

The dam is designed to reduce the velocity of percolation and thereby prevent undermining by the provision of a sufficient length for the enforced percolation. This is accomplished by means of steel sheet piling, a broad base, and upstream and downstream aprons. Under the spillway section round bearing piles, spaced 3.25 ft. center to center, are used. The crest of the spillway is 500 ft. long and 28.5 ft. high, while an additional 2 ft. of storage may be obtained by a movable crest. The foundations are also designed to stand an increase of 5 ft. in the height of the spillway. Two 9-ft.x14-ft. flood gates and a 4-ft.x 4-ft. flushing gate are incorporated in one end of the spillway. There are also two 36-in. water pipe connections, one of which is reserved for future use.

The earth embankments are 13 ft. above the crest, as previously stated, and are 1,200 ft. long, being cut approximately in two by the concrete section. The effect of the reservoir formed by this dam will be noticeable 12 or 15 miles upstream.

The cost of the entire project is estimated at $1,250,000, including land. Bids for this work will soon be advertised so that the construction may get an early start this spring.

The foregoing paper by Mr. Greeley was presented at the annual meeting of the Illinois Society of Engineers.

WATER SUPPLY SHORTAGE AT NORFOLK, VA.

It is not often that a large city experiences a water shortage but such a case has arisen in Norfolk, Va. That city was visited on Jan. 15, 1920, by engineer Robert C. Dennett for the purpose of investigating the reported shortage of water and its effect on fire protection. Mr. Dennett made the following report on Jan. 19, of his findings to the National Board of Fire Underwriters:

The city obtains its supply from a series of lakes, situated 5 to 10 miles east of the city, pumped, filtered and repumped directly to the distribution system. The normal storage in these lakes is about 2,000,000,000 gallons. Due to an abnormally low rainfall in 1918 the storage in the lakes was considerably below normal last July and since that time the rainfall has been very slight, so that at the date of this inspection the total storage was estimated to be 300,000,000 gals.

The water department has installed electric or gasoline driven centrifugal pumps at various points, which discharge into canals or pipe lines, so that all of the water in the various lakes can reach Lake Wright, on which the pumping station is located. On Jan. 16, the clear water basin, capacity 3,000,000 gals., and the coagulation basin, capacity 3,500,000 gals., were full, and Lake Wright, which is adjacent to the coagulation basin and feeds it by gravity, contained an estimated 30,000,000 gals. Considerable ground water is reaching the lakes, an amount estimated at from 5,000,000 to 8,000,000 gals. a day. Arrangements have been made so that in extreme emergency salt water can be pumped into the lakes.

The normal consumption for the city is about 12,000,000 gals. a day. In order to conserve the supply the normal pressure of 50 lbs. at the pumping station was reduced on December 4. Under present operations a pressure of 8 lbs. is carried from 10 P. M. to 6 A. M., 20 lbs. from 6 to 7 A. M. and from 5:30 to 6 P. M., 12 lbs. from 8:30 A. M. to 12 noon, from 1 to 5:30 P. M. and from 8 to 10 P. M., and 40 lbs. from 7 to 8:30 A. M., 12 noon to 1 P. M. and 6 to 8 P. M. At 1:30 P. M., on Jan. 16, the pressure was 9 lbs. at a hydrant at fire headquarters. Charts from a recording gage at the city hall in the congested value district show a minimum pressure of 8 lbs.; the normal pressure would be about 30 lbs. The city is practically level and pressures in other parts would not be lower than given above.

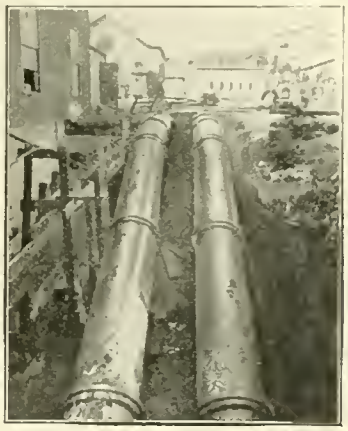
The pumping station receives all alarms of fire on a gong over a fire alarm circuit; telephone is also provided. On first alarms additional pumps are primed if necessary and on second alarms or special calls pressure is immediately increased to 45 lbs. The result of lowering the pressures has been a decrease in consumption to about 7,000,000 gals. a day.

The water now has a slight brackish taste and although tests by the city show the water to be safe there is some objection to its use for domestic purposes. The city is therefore hauling water in tanks and sprinkler carts from private supplies and distributing it to those who wish it.

Work has been started on an emergency supply from Berkley. A 14 in. submerged main crosses the river from Portsmouth to Berkley, supplied from Lake Kilby. From the terminus of this line a 16 in. main is being laid to the bridge to Norfolk, from which point a 20 in. will be laid to Water and Main Streets. Two 2,225,000 gal. electrically operated pumps will be installed at the terminus of the 14 in. line. Pipe and pumps are on hand, work is under way, and it is expected that it will be completed in three weeks. From 2,000,000 to 3,000,000 gals. a day will be available from this source.

For a temporary supply it is planned to start work

Elevating and Conveying Abrasive Material



The greatest copper reclaiming plant in the world is that of the Calumet & Hecla Mining Co., on the shores of Torch Lake, an arm of Lake Superior. Fifty million tons of mill tailings, which have accumulated here during the past 50 years, are now being dredged and pumped out through the two lines of

Cast Iron Pipe

shown here, at the rate of thousands of tons daily, to the tanks in their ammonia leaching plant. No other pipe has yet been found to withstand this severe service so well.

At the left is shown a line of 10-inch Cast Iron Pipe conveying gas house coke, in 8-inch lumps to fines, from a 7,500-ton silo to the top of grinding plant at the works of the Canada Carbide Co., Shawinigan Falls, Que. This is a pneumatic system, in which the material is conveyed a horizontal distance of 600 feet, with a vertical lift of 105 feet. The capacity is 15 tons of coke per hour with a velocity of 10,000 feet per minute. At last reports (August, 1919) this pipe showed no signs of wear after having been in service about two years.

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at once on a 20-in. main, laid on the surface of the ground, 9 miles long, from Lake Drummond. It is expected that within 90 days a supply of 8,000,000 gals. a day will be available to the city lakes.

On February 17, a bond issue of $6,000,000 for a new supply will be voted on. Plans are now being made and it is expected that work will start within 30 days. It is proposed to lay a 36 in. line to the city from Lakes Phillips and Burnt Mills, 18 miles away, to build a reservoir at the lakes, with an average depth of 12 ft. and a capacity of 3,100,000,000 gals. This will give a supply of 15,000,000 gals. a day, with further development possible. Water will be pumped and will enter the distribution system at a point opposite where the present supply enters.

The city officials appear to be well aware of the importance of maintaining adequate fire protection and are now doing everything that can reasonably be expected along these lines. They state that under all conditions enough water will be maintained in storage at the pumping station to meet the requirements of any fire. The pressure throughout the city is, of course, much below normal throughout most of the day, and this condition will continue so for some time unless there is a rainfall, but enough water for a first stream is available at any hydrant, and with the electric pumps in service, additional pressure can be obtained in two or three minutes upon call of the fire department, so that as long as the means of transmitting alarms to the station are in service and are promptly utilized when necessary for increasing the pressure, the situation in regard to fire protection cannot be considered critical.

CONCRETE IN WATER WORKS CONSTRUCTION

To the Editor: We were, of course, greatly interested in reading the article by Mr. A. C. Irwin, entitled "Concrete in Water Works Construction," published in your November, 1919, issue.

We are always pleased to see our work mentioned and illustrated in the engineering press, and we are much gratified at the general treatment of the subject in this article. We do feel, however, that in some respects the comparison made between multiple arch dams and the buttress and slab type of dam was so worded as to appear unfairly disadvantageous to the latter type.

What we mean can be shown most clearly by quoting from the article. On multiple arch dams it says:

> Some very high dams of the multiple arch type have been constructed, and plans are now being prepared for one in California which will have a height of considerably over 100 ft.

In a later paragraph the following statement in regard to the buttress and slab type appears:

> This type is especially adapted to long and low dams.

We fear that your readers will infer from this that the latter type, which is, of course, the one with which our name has been chiefly connected, is not adapted to high dams. In order to correct any such impression we are taking the liberty of writing to you and calling attention to the fact that several Ambursen dams higher than 100 ft. have actually been built. Among these are:

The dam on the Jordan river, British Columbia, for the British Columbia Railway Co., 115 ft. high and 760 ft. long.

The dam at Douglas, Wyo., for the La Prele Reservoir and Ditch Co., 150 ft. high and 325 ft. long.

The dam at Comerio, Porto Rico, for the Porto Rico Railway, Light and Power Co., 125 ft. high and 440 ft. long.

The Guayabal dam of the U. S. Irrigation Service in Porto Rico, 115 ft. high and 1,200 ft. long.

In addition to these and other high dams actually built we have from time to time prepared in this office complete designs for dams up to heights of 300 ft. and more, which have met with the full approval of consulting engineers employed by the owners of the projects. We have no doubt whatever that the Ambursen type of dam construction can be successfully carried to greater heights than any other.

In the matter of adaptability to soft foundations there is also something that we should like to add to the article. On clay and earth foundations, such as many Ambursen dams have been built upon, a continuous foundation floor is often required in order to reduce the bearing pressure to a safe value. A comparatively close buttress spacing is obviously essential under such conditions, since long spans between buttresses would make the floor extremely expensive or even practically impossible to design. We have had to solve this problem for many of the dams we have built, and we believe that with no other type can it be solved as economically as with our own.

Very truly yours,

Ambursen Construction Co.,

By Robert C. Latimer, Chief Engineer.

New York City, Jan. 14, 1920.

CHLORINATION OF SCREENED SEWAGE

The city of Stockton, California, recently installed a new Reinsch-Wurl screen for the partial clarification of the sewage from the north part of the city, prior to disposal into the San Joaquin River. Several tests on the plant were run by the Bureau during the month, the effectiveness of the screen determined and considerable light thrown on sewage disinfection. The sewage here contains considerable wastes and its chlorine consuming power ranges between wide limits, which, however, may be fairly well gauged by the flow of sewage at the time. This observation made it possible to prescribe a sliding dose of chlorine as the flow varied. The tests also indicated that the relatively crude effluent of the Reinsch-Wurl screen required only slightly more chlorine for disinfection than the same sewage settled. The difference was so slight as to be not controlling in the selection of screening versus tankage treatment under the conditions prevailing at this plant, reports C. G. Gillespie, Director of the Bureau of Sanitary Engineering of the California State Board of Health.

CONSTRUCTION NEWS AND EQUIPMENT

USE OF CHARGING BINS AND PEBBLE WASHING PLANT SAVES MONEY ON CONCRETE ROAD CONSTRUCTION

Realizing the importance of adopting all the labor-saving devices possible on concrete road construction, the Board of County Road Commissioners of Wayne County, Mich., purchased a set of R. D. Baker Charging Bins for feeding a concrete mixer. The bins and the advantages of their use are thus described in the latest annual report of the Board.

These bins are mounted on a narrow-gauge industrial railway track and are attached directly over the loading skip on the concrete mixer. They have a capacity of 8 cu. yds. of pebbles or stone, sand and cement. Inclined tracks lead from the industrial railway track up onto the top of the bins, and industrial cars are pulled up the inclined track and dumped directly into the bins. This apparatus takes the place of 7 wheelers and 7 shovelers, who shovel the pebbles or stone and sand off from the grade after it has been dumped by the industrial cars and wheeled it into the mixer skip. The cars are dumped directly into the bins, and from the bottom of the bins the material is measured into the mixer skip by a rotating drum divided into segments.

This equipment was used upon two road jobs in the summer of 1919 namely, the Romulus-Belleville Road, and on Warren Road. This plan of charging a mixer has five distinct advantages:

1st. It insures clean aggregates, accurately proportioned by machine, free from dirt shoveled off from the grade.

2nd. It saves the cost of 7 shovelers and 7 wheelers, amounting, at the 1919 wage scale, to $70 per day, or reduces the labor cost about 10 cts. per square yard.

3rd. It makes it possible to operate immediately after a rainstorm even if the sub-grade is muddy, because no material has to be picked off from the grade, and the whole outfit is mounted on industrial railway tracks.

4th. It saves materials, as no material is dumped on the grade; the usual loss of about 10% of pebbles and sand is saved; everything that is hauled out on the grade goes into the mixer by mechanical means.

5th. The sub-grade is not cut up after fine grading has been completed, as is the case where from any cause motor trucks or teams are used for hauling.

The use of this device will be extended to other road jobs under control of the Board wherever feasible.

Pebble Washing Plant at Northville

Owing to the great possibility of being held up for shipments of pebbles and sand through railroad congestion and on account of the poor yard facilities at Northville, the Board decided to lease a gravel pit if a suitable one could be found and erect a small washing plant to furnish their own material for concreting the streets at Northville and the Fishery Road. They secured a lease for a very good gravel pit at Northville at 15 cts. per cubic yard in the bank, measurement to be governed by the number of cubic yards of concrete laid.

They erected a washing plant with a capacity of 200 cu. yds. per day on this property, graded the entrance and laid their industrial railway right up to the chutes from the washing plant bins.

The location of the pit is central to the road being built, thereby shortening the haul about one-half mile over the distance from the railroad siding if they had used commercial material. The lay-out of the gravel pit is such that it was much cheaper to arrange a yard at the pit than it would have been to unload from railroad cars.

A small stream fed by local springs furnished an abundant supply of water, which was pumped 1,000 ft. through 2 lines of 3 in. pipe to the washing plant by electric motor. A single line of 4 in. pipe would have been sufficient, but the Board used two 3 in. lines because they had the pipe in stock. The plant was operated by a small electric motor, making it comparatively simple in operation.

The cost of operation was approximately as follows:

4 teams	$8.00	$32.00
2 scraper holders	5.00	10.00
1 foreman	6.50	6.50
1 operator	6.00	6.00
2 car loaders	5.00	10.00
Motor rental	1.50	1.50
Electric current, est.		10.00
Total cost		$76.00

The average daily output was 200 cu. yds., which amounts to 38 cts. per cubic yard, plus 15 cts. for the cost of the material in the pit, making a total of 53 cts. per cubic yard for the material loaded in the industrial cars ready to haul. It will be noted by the above cost that the largest item is the teams loading the hopper which feeds the belt. This could be eliminated by the installation of a drag line bucket and hoisting engine, but owing to the short run which this plant will have it was not considered advisable to invest in so large an equipment.

Commercial pebbles cost $1.25 per ton f. o. b. cars at Northville, plus about 25 cts. per ton to unload into industrial cars, making a total of $1.50 per ton, or $2.25 per cubic yard. Comparing this figure with the cost of producing pebbles and sand in the Board's washing plant shows a saving of $1.72 per cubic yard. They will use approximately 10,000 cu. yds. of material out of this pit, which makes a gross saving of $17,200 over commercial material. The plant cost approximately $7,200 to erect, making a saving on the Northville job alone of $10,000.

This year the Board expects to operate the plant a few months to furnish maintenance gravel for their 24 miles of gravel road leading from Detroit to Plymouth and Northville. This road takes from 3,000 to 4,000 cu. yds. of gravel per year to properly maintain it, and the material

Printed as insert to MUNICIPAL AND COUNTY ENGINEERING, February, 1920.

which is produced at this washing plant is excellent for this purpose.

The Board also uses a considerable quantity of coarse sand in tarring cracks and expansion joints and slight holes in their concrete road surface. The sand produced at Northville is excellent for this purpose, and can be economically truck-hauled directly to a large mileage of the roads, effecting a still further saving.

THE AUSTIN COMBINATION DRAGLINE MACHINE

The Austin Combination Dragline Machine has attracted much favorable attention in the construction field because of its ability to perform a wide variety of construction operations. By using different booms, properly equipped, this one machine solves many earth and material handling problems.

According to the boom with which the machine is equipped, the outfit is suitable for performing any one of the following operations: Excavating, ditching, trench digging, backfilling, street and road grading, cleaning

AUSTIN COMBINATION DRAGLINE WITH COMBINATION BOOM AND "SKIMMER."

ditches, loading and unloading loose bulk materials and for general hoisting work; thus, it performs the functions of a dragline excavator, power shovel, clamshell, and skimmer bucket, crane and pile driver or puller. It is important to note that this machine is equipped to use the requisite attachments by simply changing the booms and buckets. No drums have to be added. The machine is

SHOWING HOW SHOVEL DIPPER IS ATTACHED ON AUSTIN COMBINATION DRAGLINE MACHINE.

driven by internal combustion engine steam or electric power. The multipedal traction makes feasible operation over soft surfaces and the crossing of many bridges without the shorting that wheel traction would require. The

(Continued on Page 38)

Improved Way to Dig and Convey Materials

Why so many Sand and Gravel Producers, Highway Commissioners and Contractors use

Sauerman
DRAGLINE CABLEWAY EXCAVATORS

Small Sauerman Cableway operated by Double-Drum Belt Hoist driven by 20 h p. traction engine This outfit used by Illinois Township.

EACH year sees more Sauerman Drag-Line Cableway Excavators installed than any preceding year, and 1919 broke all records in this respect.

If you are not already acquainted with the reason for the steady increase in the use of these drag-line excavators for excavating sand and gravel and handling loose materials, just ask yourself this question: "What is more economical than an excavator that not only digs, but also elevates and conveys material any distance up to 700 feet and dumps at any desired point?"

There you have the answer. It is the ability of the dragline cableway excavator to dig over long spans and to depths beyond the reach of a steam-shovel or a boom dragline excavator, and particularly its economy and efficiency in handling materials from under water that have influenced so many sand and gravel operators to give preference to this type of equipment.

A Sauerman Dragline Cableway Excavator is economical to operate. One man at the levers of a two-drum hoist controls all the operations of digging, conveying, elevating and dumping. After dumping, the bucket returns to the digging point by gravity.

The experience of the Sauerman organization of engineers is at your service if you have a gravel deposit to develop, levees to build, pond or river to clean out, overburden to remove or any similar work involving excavating and moving of loose materials.

If you have never had a copy of our 130-page illustrated catalog, write for one today.

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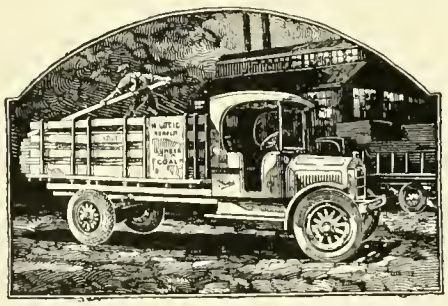
GARFORD



Nothing so clearly demonstrates sound engineering and right manufacturing as the ability of Garford Motor Trucks to give

—Low Cost Ton-Mile.

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Lima, Ohio

TRUCKS

The GOOD ROADS

Made Good to Make Good Roads

GOOD ROADS Machines are built with full knowledge of the service they must deliver.

That knowledge is the natural result of over 43 years invested in developing the GOOD ROADS line.

And the GOOD ROADS Machinery Company has the distinct advantage of knowing well the needs of road makers. *Your* needs.

So it has been the aim of the five factories of this great company to produce machines and equipment with certain essential qualities:

Design, advanced—first proven practical in actual service.

Material, sturdy and lasting—always a little better than the service calls for.

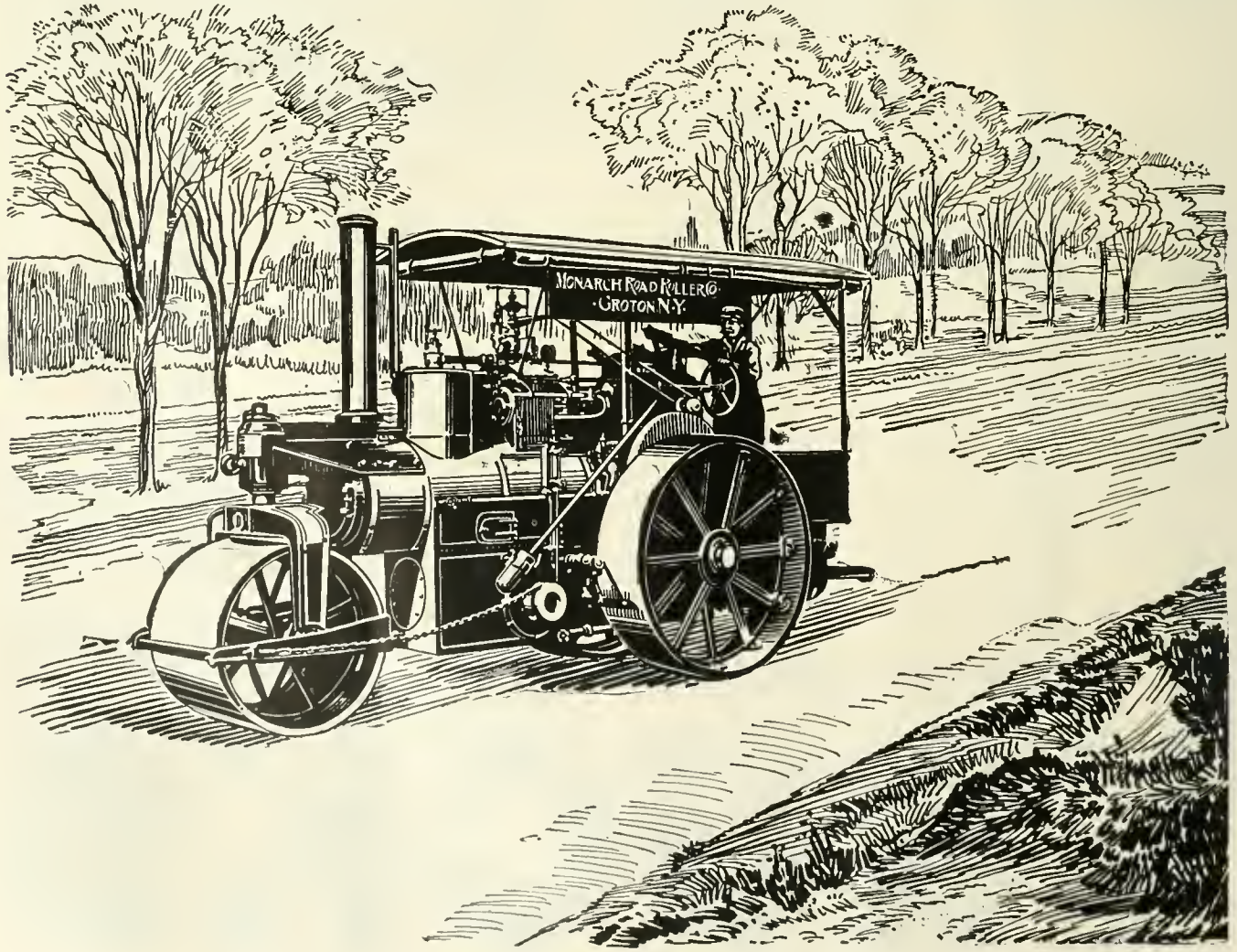
Workmanship, without question the finest to be had—to accord strictly with the G. R. M. Co. standard.

Type, that demanded by its users and the working conditions to be met—"tools to fit the job".

Surely and well this work has gone on. Until—Today, the GOOD ROADS Machinery Company offers a product for every street and road building use. So, we add—

Service, "Everything for the Road Maker".

This means that you can get your road grader, roller, rock crusher, oil distributor, culvert pipe, heating kettle, road drag and so on, *all* from one source.



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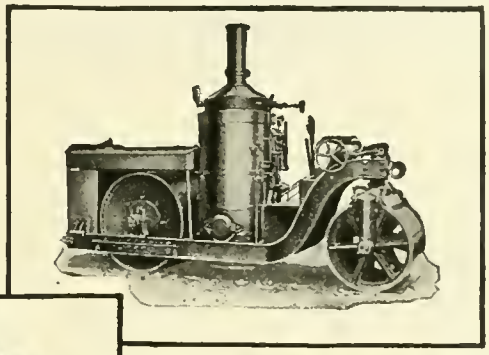
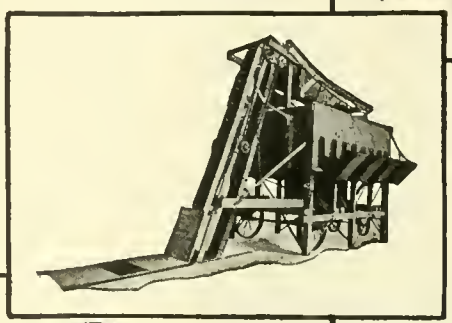
Monarch Tandem Road Roller made in 5-, 6-, 9- and 10-ton sizes.

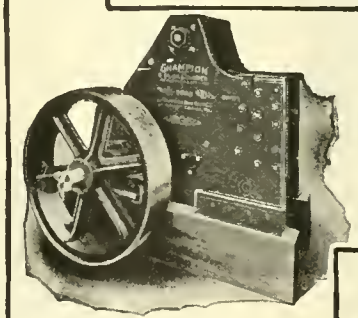


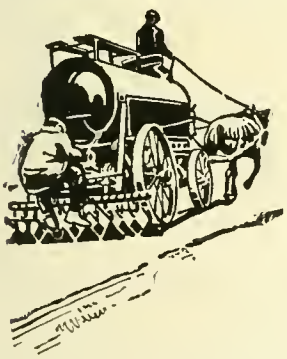
The Winner Portable Gravel Screening Plant.



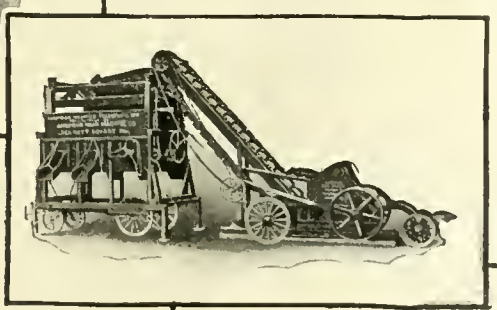
No. 4½, 10 x 20, Champion Steel Rock Crusher on sills.

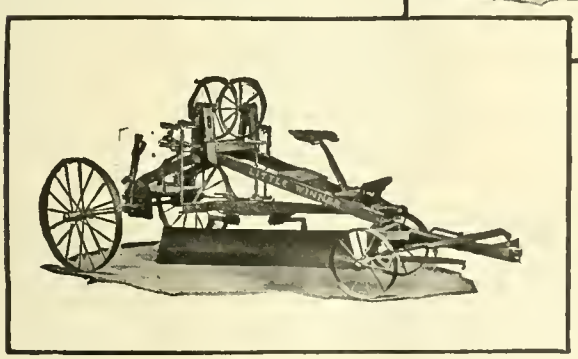
Monorch Roller with Scarifier Attached.





Monarch Pressure Oil Distributor.





Champion Portable Crushing Outfit, consisting of a crusher, mounting elevator, screen and portable stone bin.

The Little Winner Steel Reversible Road Grader.

Monarch four-wheeled Heating Kettle.

(Concluded from Page 34)

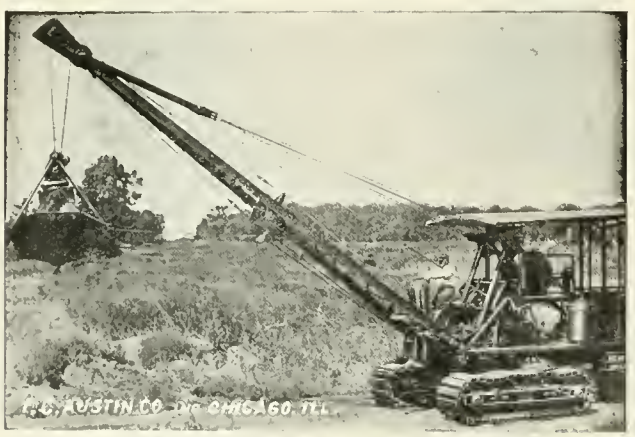
machine is of all-steel construction and of light weight. It is operated by one man.

The design of the boom and skimmer bucket permits straight crowding or skimming to a length of about 14 ft.

AUSTIN COMBINATION DRAGLINE MACHINE EQUIPPED WITH 30-FT. BOOM, CRANE AND HOOK.

This far exceeds the capacity of the ordinary steam shovel of like yardage for road grading and construction. As a shovel, the machine is fast and powerful. It revolves in complete circles and excavates and dumps in any direction.

Equipped as a crane, it possesses speed, economy, durability and portability. As a clamshell excavator it meets



AUSTIN COMBINATION DRAGLINE MACHINE HANDLING ONE-HALF YARD CLAMSHELL BUCKET.

the requirements of a fast, portable and efficient excavator of the clamshell or orange peel bucket type.

The accompanying views show the machine with combination boom and skimmer, with power shovel attachment, with a 30 ft. boom crane and hook, and with a clamshell bucket. These views give an idea of the range of work possible with this machine which is manufactured and marketed by the F. C. Austin Company, Inc., Chicago.

DESIRABLE FEATURES IN JOINTED BLADE ROAD MAINTAINERS

There are several kinds of jointed blade road maintainers on the market. Any type possessing the following features is recommended by the Department of Public Works of the State of Nebraska:

1. The wheel base should not be less than 13 ft. and the frame well stiffened.

2. The blade should be hung midway between the front and rear axle.

3. The blade should be equipped with a locking device so that when the blade is once adjusted it can be kept in position.

4. The maintainer should be equipped with a device, so that all of the segments can be lifted at once.

5. The mould board should be so designed that the dirt will roll along in front of the board and not deposit at the sides.

6. The rear wheel should be set in from the end of the blade so that fills can be dressed to the shoulder line without having the wheel break down the fills. The rear wheel should also clear any bumps that spill from the end of the blade.

The patrolman operating a jointed blade maintainer should always have his blades sharp. He should provide himself with an extra set, so that his machine will not be laid up when it becomes necessary to sharpen the blades.

The machine should be well greased. This means that all working parts must be thoroughly lubricated including the chains of the raising and lowering devices.

In operating a maintainer it should be thoroughly understood that the machine is designed for maintenance alone, and not for grading the road.

The blade should always be set level with the bottom of the front and back wheels.

In making the first round the outer blade should be in the ditch at a slope corresponding to the finished cross-section of the road. The remaining blades should be set to conform to the finished surface.

The inside slopes of the ditches must be kept free from weeds; unless this is done the maintainer can not be worked successfully. This slope is the source of supply of clear dirt for building up the shoulder of the road; also all of the dirt that is washed into the ditches by rain is brought to the road over the inside slope of the ditch.

The best time to use the maintainer is when the earth contains moisture enough to work well and not stick on the blade.

The best speed to operate the maintainer is from 4 to 5 miles per hour.

The object of the maintainer is to cut off bumps and fill depressions. For a while the operator will be called upon to use some skill in accomplishing this, but after a while he will have the road in such shape that the amount of dirt carried in front of his mould board will be uniform. The road then will be in perfect shape, and practically no adjustment of the blades will be required by the operator.

A truck or tractor is the best power for a maintainer.

A complete outfit with motor power and maintainer requires two men, one driver and one operator.

NEW MACADAM ROLLER DESIGN

Since the invention and perfection of the macadam road roller some thirty or more years ago, there has been practically no change in design. After many years of experimental work and tests under actual working conditions, the Iroquois Department of The Barber Asphalt Paving Company has perfected and

(Continued on Page 40)

Your Success Depends on Quality Equipment

YOU are selling square yards of concrete. Maximum dollars will be to your credit in the bank this year if you do two things —use a Smith Simplex Paving Mixer and organize your loading schedule to keep up with Smith Simplex speed.

You can't crowd a Smith Simplex. It is faster than the fastest loading scheme. And it's a steady, dependable machine—surprisingly simple, adaptable to every requirement of road construction, economical in operation, sturdy and powerful.

Don't experiment this year. Buy a Smith Simplex.

Investigate the advantages of the Band Friction Hoist, interchangeable Boom and Bucket or Swivel Chute delivery, interchangeable caterpillar or wheel traction, highest drum built, central drum ring, worm gear automobile type steering mechanism, actual one-man control—as found only in this Paver!

Three Sizes—10E, 14E and 21E

"101 Reasons" is an interesting booklet—Write for it

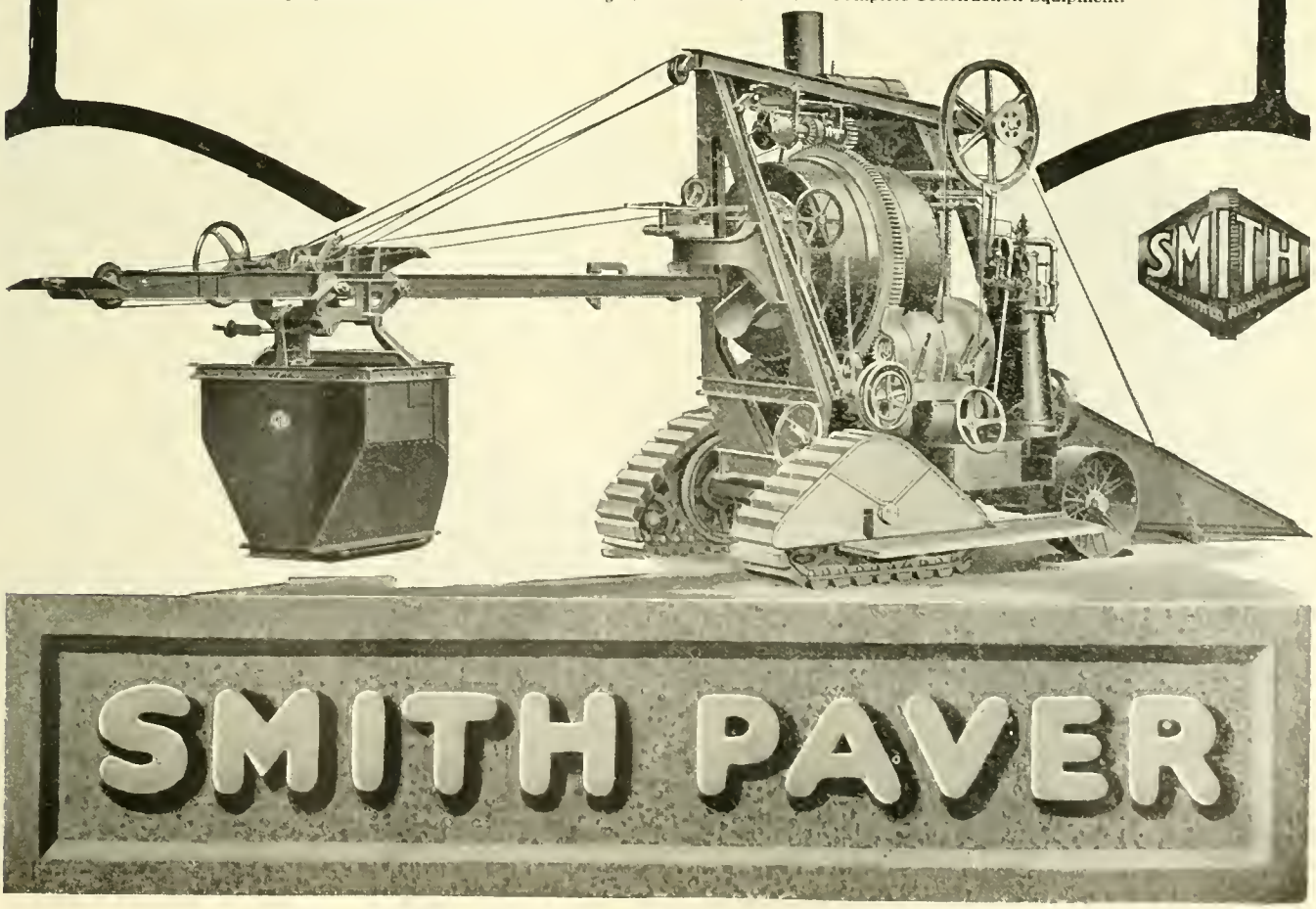
THE T. L. SMITH COMPANY

471 OLD COLONY BUILDING

CHICAGO ILLINOIS

Factories at Milwaukee, Wisconsin

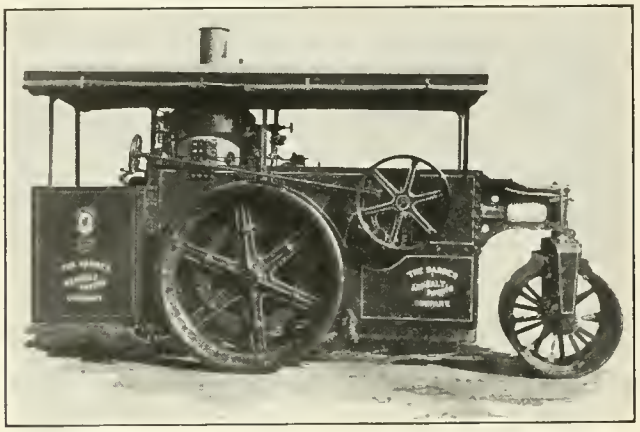
Smith Tilting Mixers—Smith Non-Tilting Mixers—Smith Simplex Paving Mixers—Smith Excavator and Loader—Smith Pumping Outfits—Smith Gas and Steam Engines and Boilers—Hoists—Complete Construction Equipment.



(Concluded from Page 38)

placed on the market an entirely new type of macadam road roller.

The most noticeable feature of the new Iroquois Roller is the vertical boiler which rests upon the steel framework of the roller itself, a separate unit to which nothing is bolted, thus relieving the boiler from any of the wracking strains and weights imposed upon the horizontal boiler of the old type macadam



SIDE VIEW OF NEW IROQUOIS MACADAM ROAD ROLLER SHOWING BELT WHEEL FOR OPERATING STONE CRUSHER OR OTHER EQUIPMENT.

roller. The boiler of the new Iroquois macadam roller may be easily removed for repairs without disturbing any other part of the roller. It has over 50 per cent. more heating surface than in the old type roller.

Extreme accessibility and simplicity is the keynote of design and every part is so placed that it is "get-at-able" and ruggedly constructed of the best material to perform the work required efficiently and economically.

The engine is also a separate unit and rests upon the roller framework, on a three point suspension that has demonstrated its many advantages in automobile construction.

The drive is accomplished through a differential gear to the rear wheels. This may be locked out for hard straight pulls. Positive steer is assured through a steel quadrant that prohibits the front roll dragging and shoving up the surface of the highway. The rear wheels are equipped with demountable rims, easily renewed when worn.

A steam scarifier is part of the standard equipment. It is adjustable, scarifying any depth desired the full width of the roller, in the hardest kind of material; a performance which has never been equalled by any other roller.

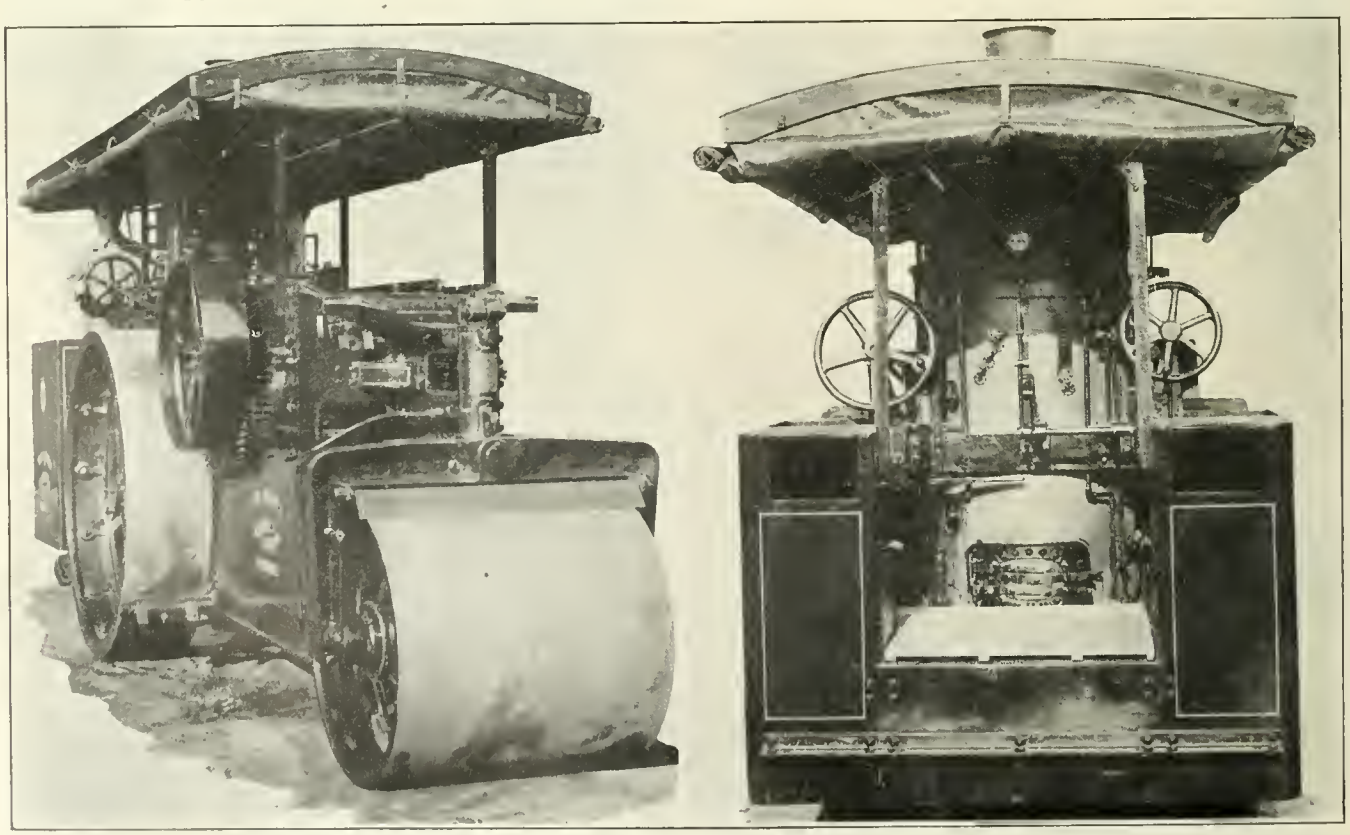
Shifting of gears is entirely eliminated and speed changes are made unnecessary, as the engine is much more powerful than in the old type roller, due to higher steam pressure and larger engine cylinders. It has all the flexibility in operation of a tandem roller.

Despite the high appearance of the roller, the center of gravity is in reality lower than on the old type, absolutely prohibiting any danger of tipping over. The boiler is equipped with a feed water heater to insure economy in operation.

MODERN USES OF TRENCH EXCAVATORS

By J. McElroy, Sales Engineer, Pawling and Harnischfeger Co., Milwaukee, Wis.

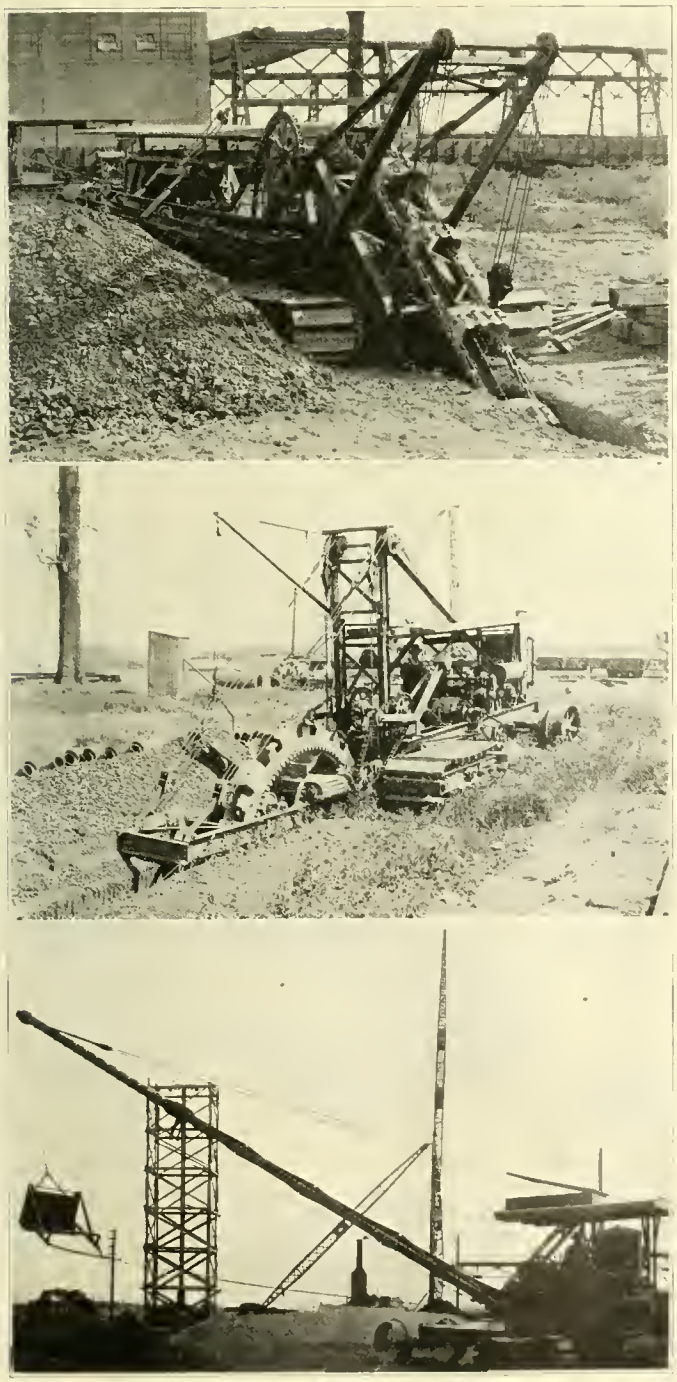
The use of a trench excavator, some years ago, was considered somewhat foolhardy. Contractors felt that



VIEWS OF NEW, VERTICAL BOILER, IROQUOIS MACADAM ROAD ROLLER.

BARE COST OF OPERATING TRENCH MACHINES, NOT INCLUDING PIPE GANG

Maximum Capacity	Fuel Used in Gallons in Ten Hours	Hard Grease and Waste	Lubricating Oil	6% for Full Year 10% for Season Int. on Investment Daily Rate	Life of Machine 10 Years Depreciation per Day	Estimated Cost of Repairs, 200 Working Days	Salary of Operator and One Helper	Estimated Capacity Lineal Feet in Ten Hours	Average Delays in One Season	Cost per Lineal Ft.	Cost per Cu. Yd.
4½ ft. x 23 in.	20	$0.20	$0.40	$2.00 per day	$2.50 day	$2.00 day	$12.00	2,500	20%	$0.012	$0.06
4½ ft. x 24 in.	25	.20	.40	2.25 per day	2.75 day	2.25 day	12.00	2,250	20%	.014	.035
5½ ft. x 18 in.	25	.20	.40	2.25 per day	3.00 day	2.25 day	12.00	2,250	20%	.015	.05
6½ ft. x 24 in.	35	.20	.60	2.50 per day	4.00 day	3.00 day	12.00	2,000	20%	.02	.04
7½ ft. x 28 in.	35	.20	.60	3.00 per day	4.00 day	3.50 day	12.00	1,500	20%	.026	.042
12 ft. x 31 in.	30	.20	.40	3.00 per day	4.00 day	2.50 day	12.00	1,000	20%	.037	.032
15 ft. x 42 in.	35	.20	.60	3.00 per day	4.00 day	3.00 day	12.00	600	30%	.08	.04
18 in. x 42 in.	40	.20	.90	4.00 per day	5.00 day	4.00 day	12.00	500	40%	.12	.05
Backfiller	8	.10	.20	1.00 per day	1.50 day	.50 day	6.00	800 to 1,000 cu. yds.	10%	....	.015



LADDER AND WHEEL TYPE EXCAVATORS AND BACKFILLER, OF PAWLING & HARNISCHFEGER MAKE, SHOWN IN OPERATION.

they would rather use hand labor on which they could figure a positive daily yardage or nearly so, than to gamble on a heavy, cumbersome machine which might run for an hour and then stop for a week. At the present time heavier trenching machines have reached a high state of efficiency which makes them almost indispensable to the ditching contractor, not alone on account of their increased productivity but also because the hand laborer, or old time "navvy," is fast becoming an extinct species.

Trench machines were first used on deep sewer work alone. Now, however, we find them used on sewer, water, gas, telephone conduits, farm tile, and oil pipe lines and even excavation for curb and gutter. The use of trench excavators is no longer in the realm of experiment and the matter of trench excavating has narrowed down to a selection of the model and type of machine best suited to the work in hand. On sewer work the best type is the ladder or boom type. This style has a longer range of depth than the wheel type machine. Another feature of the ladder type machine is its flexibility. It can be readily extended to dig to greater depth by applying an extension to the ladder, always providing of course that the component parts of engine and frame will carry the added weight of the ladder extension.

On gas, water, conduit, farm tile, and curb and gutter excavation the wheel type machine is preferable. For any work less than 8 ft. deep the wheel type machine is the better. The mounting of scoops or buckets on the periphery of a wheel, which in turn is hung on a frame suspended by cables at front and back, gives a circular digging action. More buckets are thus engaged in the actual digging at one time than is possible with the ladder type which digs in a straight line. After many tests it has been found that the wheel type machine will dig more frozen ground and hard material than the ladder; in fact, it will dig to the same depth faster, both machines having equal power. This result is apparent because of the more rigid digging action of the wheel type machine.

On the other hand the ladder type machine has the advantage of being able to dig backwards or to tunnel under obstructions, such as gas and water pipes. The mounting of the buckets on the ladder gives greater clearance for the excavated material. It is possible, to overload the buckets and to drag boulders which are even larger than the buckets themselves, these boulders being finally pushed up on to the conveyor. Such performance is not possible on the wheel type machine owing to the limited space between bucket and wheel.

Machine operators can make a success or failure of a

trench machine, so it is important that a man be properly trained for this work. It is usual and sensible to have a backfiller following the trench machine after the pipe is laid. A very successful form of backfiller is the miniature dragline mounted on caterpillars with a boom and self-filling scraper. This machine requires but one man to operate. The two types of trench excavators and the backfiller are illustrated herewith.

The accompanying table gives approximate costs of operation of trench machines of both types and also a backfiller. This data can be considered only as an average, as capacities are always subject to local conditions.

Contracts Awarded

ROADS AND STREETS

Ala., Selma—Alabama Paving Co., Birmingham, awarded contract for paving Selma Ave., at approx. $65,000.

Ariz., Yuma—L. M. White and C. M. Miller, Yuma, awarded contract for paving Second Ave.,—1st to 8th Sts.,—approx. 5,000 ft., at $76,161.

Ark., Arkansas City—Desha County Road Impvt. Dist., No. 2, awarded contracts to following for construction of 110 mile road, Warrenite on concrete base and gravel; brdgs., etc.: Sects. 1, 2 and 3 and 5 to Warren Bros., Boston, Mass., Sects. 4 & 6 for gravel surfacing, to $459,784 to Perdue & Hill, Pine Bluff, Ark.; grading, grubbing and clearing at $500,000 to Arpin Bros., Wisconsin. Cost of Warren Bros., contract. $2,717,500.

Ark., Jonesboro—Roach & Shuford, Memphis, Tenn., awarded contract to construct 16.25 miles of road; gravel; $150,000.

Cal., Bakersfield—Rogers Bros. Co., Los Angeles, awarded contr., for paving with concrete the Fellows-McKittrick road, at $369,000.

Cal., Dixon—Ransom-Randle Co., Sacramento, awarded contract for improvement of 23 blocks Warrenite pavement, concrete and cement gutters, etc., at $151,508.

Calif., Gridley—Clark & Henery, awarded contract for paving 30 blks. of streets here, at $165,286.

Cal., Los Angeles—Geo. R. Curtis, 2440 E. 26th St., awarded contract for paving Temple St.,—Vermont Ave. to Wilton Place—also sewers, and sanitary, at $139,910.

Cal., Los Angeles—D. L. Gaskill, 236 Hermosa Ave., Long Beach, awarded contract for grading roadways and constructing curbs and walks in 8.5 miles of streets in Graham, known as Rd. Dist. Impvt. No. 151 at $114,730.

Cal., Los Angeles—T. E. Hill & Co., 1011 Washington St., City, award. contract for improving approx. 8 miles of Santa Paula-Ojai Road, of which 4 miles is to be paved with concrete, at $115,494.

Cal., Los Angeles—Geo. R. Curtis, City, awarded contract for street and sewer impvts. on Temple Street—Vermont Ave. to Wilton Pl.—at $139,910. Job involves 341,023 sq. ft. paving (asph.), grading, curbing and large conc. storm drain in Temple St

Cal., Fresno—Thompson Bros., Fresno, awarded contract for paving 5.35 miles county highway on Blackstone Ave., at $96,978; also contract for paving 11.99 miles on Elm Ave., with black base and Warrenite top, at $228,660.

Cal., Fresno—Hugh Crummey, San Francisco, awarded contract for paving 6.01 miles on Sect. A, Route 33, County Hwy. with 5-in. asphaltic concrete, Warrenite type, at $139,455.

Conn., Hamden,—Sperry Engineering Co., 82 Church St., New Haven, awarded contract for paving 2½ miles of highway (concrete) at about $100,000.

Cal., San Diego—David H. Ryan, local, awarded contract for paving 5 streets in Brawley, at $128,000.

Ga., Columbus—Cooper Campbell, awarded contr. for constructing paving on Second Ave.,—17th street to 30th; 6th Ave.,—14th to 15th; on 15th st.,—Broad to Second—at total cost of $200,000.

Ga., Macon—W. Z. Williams Constr. Co., awarded contract by Bibb County Commrs., for constructing 6 2-3 miles Dixie Hwy.,—Macon to Jacksonville (69.844 sq. yds. conc. paving) at $232,225.

Ga., Sylvester—Speed Parkers, Inc., Louisville, Ky. awarded contract for paving approx. 3½ miles of rd. on Sylvester and Albany Road. Est. cost $100,000.

Ind., Anderson—Madison Constr. Co., Anderson, awarded contract for impvt. of Carrol Road—abt. 3 miles no. of Alexandria, at $92,600.

Ind., Delphi—J. C. O'Connor & Sons, City, awarded contracts for construction of concrete roads, in Wabash Co. (2) at $151,780.

Ia., Reinbeck—Bryant Asphalt Paving Co., 807 Black Bldg., Waterloo Ia., awarded contract for street impvts. consisting of following: 35,000 sq. yds. Bitulithic, as $104,000.

Ky., Harrodsburg—Lutes & Co., Lexington, Ky. awarded contract to construct 7 miles of road—Shakertown to Harrodsburg—at $88,000.

La., Franklinton—G. W. Prutzman & Bonnerdell & Lang, awarded contracts by Washington Parish Police Jury, for constructing 23 mi. Franklinton—Pearl River Hwy.; Sects. A-1 and A-2; gravel; 11.97 mi. Franklinton—Mississippi State Line Hwy.; gravel, $408,000.

La., Monroe—Porter & Boyd, Charlotte, N. C., awarded contract to construct Jackson Hwy.—Monroe to connect with Charlotte Savannah Hwy. at $500,000.

Mass., Cummington—M. L. Camarco, Lee, awarded contract for road, at $192,464.

Mass., Quincy—Coleman Bros. Marginal Street, Chelsea, awarded contr. for paving Furnace Brook Parkway, at $150,000.

Mich., Gaylord—Midland Constr. Co. Midland, awarded contract for grading, draining and surfacing 6.169 miles of State Trunk Line Road, at $131,414.

Mich., Lansing—Beaverton Constr. Co., Beaverton, awarded contract for Rd. 30-3, Gladwin Co., 6.443 mi., at $98,360. Gohr Bros., Lansing, contract for road no. 265, Clinton Co., 7.411 mi., at $112,435.

Mich., Lansing—Gohr Bros., 1433 Ada Street, Lansing, awarded contr. by State Hwy. Dept. for grading and surfacing 7.411 miles Assessment Dist. Rd. no. 265 at $112,435.

Minn., Duluth—D. H. Clough & Co. awarded contract for 50 blocks of concrete street and walks. Appropriation of $2,000,000 made for this improvement.

Mo., St. Louis—Louis Rich Construction Co., East St. Louis, awarded contract for constr. of series of hard surfaced roads in Arkansas, at $2,000,000. First unit is 72½ miles long and company estimates it will take two years to finish same. It will be of bitum. macadam constr. 63 rein. conc. culverts will have to be built.

Neb., Aurora—C. C. Chapin, San Antonio, Tex., awarded contr. for paving, at $345,000.

Neb., Blair—Western States Co., Omaha, awarded contract for paving 33,935 ft. main streets, 25 ft. wide, involving 78,823 sq. yds. concrete, at $288,043.

N. M., Santa Fe—Michou, Millar Clark, Teyssier, Box 272, Santa Fe, N. M. awarded contract for constructing New Mexico Fed. Aid Prop. no. 1-b, Colfax Co., involving 14.37 miles of road at $149,546.

N. Y., Brooklyn—Brooklyn Alcatraz Asphalt Co., 407 Hamburg Ave., awarded contract for furnishing labor and material for improving East Drive, Prospect Park, at $127,041.

If you would be SAFE

when you use sand

you must test it for cleanness and grade.

Here is where the

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EDITORIALS

ARBITRARY ENGINEERING STANDARDS

Certain more or less arbitrary engineering standards we must have in the interest of safety, but it is quite easy, and not uncommon, to be too arbitrary. Disclaiming intention to criticise an individual, we use a specific case here merely as an example to demonstrate the principle involved.

In a certain State an engineer, with mandatory powers, has ruled that in the water filters of his State the effective size of the filter sand shall be 0.3 millimeter. This is the text-book standard of fifteen years ago, when the art was comparatively young. Latterly filtration experts have used an effective size of from 0.4 to 0.5 millimeter with entirely safe results. This 0.1 or 0.2 millimeter difference in the diameter of the average sand grain produces a marked effect on the cost of filtration. The finer the sand, the smaller the interstices and the greater the tendency to clog. Thus the use of the fine grains arbitrarily specified makes necessary the use of an undue quantity of filtered water for filter washing purposes, and correspondingly increases the cost of operation without any compensating gain.

An even more arbitrary ruling has been made on the bacterial content of the filter effluent *prior* to chlorination. It is prescribed that 80% of the 10 c.c. samples shall give a negative result. This is apparently based on the U. S. Treasury Department Standard for purity of *sterilized* drinking water on trains and boats, where the source of the water is unknown and where it is held in small containers surrounded by warm air favorable to a high rate of multiplication of bacteria. Thus the unsterilized filtered water of known origin is made to conform to the standard of purity of sterilized water of unknown origin. Clearly this is carrying an arbitrary ruling to an absurd length, even in the interest of safety to human life.

Just what this ruling means in one city of the State is easily shown. Prior to the promulgation of this rule a certain plant had used one grain of alum per gallon and, with sterilization, was producing a safe effluent. To meet the requirements of the standard it has been found necessary at this plant to use two grains of alum per gallon. This represents an annual increase of seven thousand dollars in the operating expenses of the plant. This expense, borne by a single community, can hardly be justified, as it represents the application of a ruling which is extreme.

WHO KNOWS?

This journal stands for good construction, whatever construction material is employed. Merit is recognized in many types and classes of materials and the fact is frankly recognized that there are right and wrong ways to use each material. Who knows the right ways and is qualified to advise against the wrong ways? Engineers, of course, but let us not be too narrow in our definition of the word. Technicians employed by proprietary interests are often, if not usually, very good engineers and the proper writings of these men are of the highest value in building up good practice.

While it is true that articles merely calculated to promote the sale of this or that material have no place in the reading pages of the engineering journal, it is a fundamental and mischievous error to assume that all articles written by engineers connected with material interests are merely advertisements in article form. Such an assumption is as ridiculous as it is unfair. It is unfair not only to the author, but to the publisher as well.

When an engineer who is frankly and openly connected with some recognized material interest tells how to use that standard material in order to secure the best results, all would do well to listen, for he knows what he is talking about, and he is more interested than any other engineer can be in seeing his material handled in the manner best calculated to give satisfactory service to the public. The proper use of his material is his greatest study and its misuses cause most of his worries. He can be depended upon, therefore, to have all the latest information at his finger tips on how to use his material successfully.

Consequently, while we prize most highly articles by engineers without commercial affiliations, we frequently invite engineers directly interested in this or that standard material to advise our readers just how to use that material to secure the best results. Such writers nearly always rise to the occasion and stick to the text. Paragraphs taking playful side-swipes at the opposition are deleted by the censor prior to publication. But such paragraphs are of infrequent appearance.

Our editorial policy on this point has unmistakably won the approval of our readers as numerous letters have shown. This same plan was utilized, it is interesting to note, at the recent annual convention of The American Road Builders' Association. Engineers identified with concrete, brick, bituminous macadam, bituminous concrete and surface treated macadam and gravel, respectively, addressed the convention on new developments in proper construction of and bad practices which should be eliminated in the use of these standard materials of construction.

DOUBLE ENGINEERING EXPENSE

Hiring a real engineer to do engineering work is a good way to save money. Examples of the opposite practice are all too numerous. Recently a certain city hired an architect to prepare the plans for a modern water purification plant of the mechanical type. This is practically certain to mean a double expense for the engineering on this job. The architect, a good man and true for all we know, but innocent of any practical knowledge of water filtration engineering, will draw up the plans and submit them to the various filter equipment companies. One look at the plans and the experienced eyes of the filter men will see the necessity of a complete revision of the architect's plans, and the figures submitted by them will very properly cover this extra expense. And that isn't all; something more will be added, again very properly, for the hazards of dealing with a tyro—something every contractor understands.

The economy of hiring a competent engineer in the first place is as well illustrated in connection with water filtration as with any other branch of engineering. The architect is unaccustomed to the type of structural problems incident to water storage, and he is prone to place his reliance in reinforcing steel rather than in heavy concrete walls. Seepage does the rest, and in a few years the reinforcing in his thin walls rusts away with results we need not picture. The general engineering practitioner, on the other hand, is likely to make his walls too thick and his reinforcing too light. The result is awkward and expensive construction. Either way the engineering costs more than it should. The safest and most economical plan is to hire an expert in the first place in any highly specialized line of engineering work.

USING EMPLOYMENT AGENCIES

Many engineers are very outspoken in their hostility to every form of engineering employment agency, whether conducted as a private business enterprise or along co-operative lines. Feeling that such total condemnation of efforts by a third party to bring employer and employe together often works a hardship on all parties, we are moved to say a word in defense of the idea of maintaining these employment clearing houses.

The employment agency operated as a private business has rendered satisfactory service in so many lines that one wonders why it should not work equally well in connection with engineering. Among teachers, for example, agencies stand well. There are several which command the confidence of high school superintendents, college professors and college presidents. Many of the highest positions in the teaching profession have been filled with general satisfaction through the functioning of teachers' agencies. The average business man, as everybody knows, frequently uses the employment bureau in hiring stenographic and clerical help for his office.

If teachers of engineering and general office help can be successfully secured through the agency there is no reason why engineer employes cannot be satisfactorily secured in the same way. In hiring other kinds of help, moreover, it is just as difficult to get the right kind of material as in hiring young engineers.

Before fixing the blame for the alleged failure of engineering agencies let us examine the nature of the complaints made against them. Taking first the private agencies, one frequently hears them denounced as mere exploiters of engineers. They are criticised on the grounds of sharp practice of one sort or another. It is said they charge exorbitant fees and will recommend any engineer for any engineering job so long as the agency fee is paid. Of such practices, some of which have come to our attention, there can be no defense, and certainly we do not wish to be understood as offering a defense of abuses of the agency idea, but we are concerned in seeing its legitimate uses appreciated. Some employers of engineers are so prejudiced against agencies that they refuse to deal with an engineer who has registered with one. This is carrying prejudice too far, and an employer who entertains such a narrow view raises a serious question as to his own fitness.

Some engineering societies strive to help their members get positions and maintain employment departments for that purpose. We have never heard their integrity assailed or their good intentions questioned, but recently we heard an employing engineer damning a certain engineering society and all its works because the employment department had sent him an unsatisfactory engineer employe.

Wherein lies the difficulty? Why is the employment bureau plan less successful among engineers than in other lines of business?

The fault rests largely, if not entirely, with the employer. He expects too much of the third party to the transaction. He should realize that the function of the agency is to furnish applicants, and he must choose one applicant for himself in the light of his own requirements.

The ordinary business man would have no end of trouble if he hired the first office assistant sent in response to his call on the employment bureau. He has learned that he must interview several applicants for a single position and determine their fitness for his service by various tests. Equal care in employing engineers will insure equally good results.

There is a place for the honest engineering agency, whether operated for profit or as a form of service along co-operative lines. But employers of engineers must learn how to use these agencies. They must remember that the individual engineer is not a standard, trade-marked product, and that they can't get just the man they want in all cases by one telephone call or one letter to a third party.

MOTOR FEES AS A BASIS FOR HIGHWAY CONSTRUCTION BOND ISSUES

By S. E. Bradt, State Superintendent of Highways, Springfield, Ill.

The clippings that come to my desk indicate that some people far away from Illinois and unfamiliar with Illinois conditions are taking occasion to criticise our plan of promoting highway construction. These same people claim to speak for the motorists of the country, saying that the motor fees should be set aside for maintenance purposes, rather than for construction or a basis for bond issues. They claim that the use of motor fees for construction purposes is inequitable because all people receive a benefit from road improvement and that the direct benefits to the motorist are incidental and secondary.

Who Are the Motorists?

Who are these motorists whom they claim to represent? Are they a separate and distinct class of our people separated by a peculiar profession or occupation? The fact is that these motorists are the farmer; the miner; the merchant; the mechanic; the banker; the shopman; the lawyer; the doctor; the preacher and finally the legislator, who makes our laws. They are the men who approve or disapprove through their ballots all unusual matters of taxation which include bonds and special levies for road improvement. They pay 100 per cent of the motor fees; and probably over 90 per cent. of the general taxes. There are at the present time approximately 7,500,000 cars registered in the United States. Later estimates claim the number registered will be 10,000,000 by the end of 1920. Counting a car to a family of six persons you will find that 45,000,000 of the 110,000,000 of the people are motorists in the proper sense of the word. In the State of Illinois these motorists constitute approximately 50 per cent. of the population and hence 50 per cent. of the voters and if they are 50 per cent. today they will soon be 60 to 75 per cent. It is from this 50 per cent. of our people that 90 per cent. of the legislators are drawn. This proportion is not the same in all states. In some of the states the motorists are more than 50 per cent. of voters; in other states less; but they constitute the active, influential force in every community and every state.

This motorist is a man who thinks for himself. He knows conditions in his own state and he knows public sentiment. He has assigned to no individual or organization the right to speak for him; he has no advocate or special pleader; no one holds a brief for him. He will brook no interference from special interests either outside or inside of his state. He is his own boss; and if he prefers to take the money for highway improvement out of his right hand pocket or his left hand pocket, it is his money and his own affair; and you can depend upon it that he will settle that question without interference or assistance.

Facts About the Illinois Plan

These clippings indicate that the writers are not familiar with the Illinois plan. They give the impression that the entire road improvement in Illinois is paid from motor fees. The fact is that the people of Illinois have said that the state-wide system of 4,800 miles shall be improved from the proceeds of bonds, which are to be liquidated from motor license fees. This 4,800 miles constitutes, however, only 5 per cent. of our 96,000 miles; thus there remains 91,200 miles to be improved by general taxation and the motorist instead of being called upon to pay the entire cost of highway maintenance and improvement in the State of Illinois is only paying for the improvement and maintenance of 5 per cent. of the Illinois roads. To show what is being done by general taxation let me say that the counties of Illinois have already voted approximately $15,000,000 in bonds for road improvement; and if satisfactory conditions for construction, as to car service, supplies of material, labor and contractors, could be relied upon so as not to interfere with the state program, not less than $75,000,000 additional would be submitted to the voters in about 40 counties of Illinois during 1920.

All county bond issues must be paid by general taxation. It is not necessary to state that during the life of the bonds which are to be issued by the state and paid by motor fees a sum several times as large will be voted by the counties and townships to be paid by general taxation.

Illinois has at the present time approximately 600 miles of hard surfaced, state constructed roads which it is obliged to maintain and which it is maintaining from motor license fees with about $100,000 per year. The remaining roads of the state are maintained by the local authorities which heretofore have been raising about $8,000,000, but which hereafter are entitled to raise in excess of $12,000,000 per year for that purpose. The revenue from motor fees is in excess of $5,500,000 with only $100,000 reserved for maintenance. What would our friends suggest that we do with the $5,400,000?

What the People Voted for

With the maintenance of our roads taken care of and only a very small part of the roads properly improved the voters of the state decided by a vote of 660,000 to 154,000 that this money should be made a basis for bonds and the proceeds of the bonds used to construct a system of main traveled thoroughfares, the construction to be of such type as would give a maximum amount of service at a minimum maintenance cost. A more equitable and sensible solution of the problem could not well be devised.

As I have indicated Illinois is at present maintaining and proposes in the future to maintain its state roads from motor license fees and it is apparent that these fees will not only maintain these roads but will furnish sufficient funds to retire the bonds which we propose to issue for construction.

Direct Benefit to Motorist

Some critics contend that the motor tax is inequitable and uneconomic when used for construction purposes, because, as they claim, it fails to recognize the fundamental basis of taxation; namely, that the taxes should be levied in proportion to the benefits. With this we disagree. We all recognize that there are certain indirect benefits coming to every citizen of the state, including the motorists, from highway improvement. This is amply taken care of through general taxation. We also know that by far the greater benefit is a benefit accruing directly to the users of the road. Is there any reason why we should be prevented from paying for that direct benefit? No one realizes the direct benefit more than the motorist, and he is invariably willing to make a reasonable payment therefor.

The motor license fee law of the State of Illinois comes nearer to applying the fundamental principle, above referred to, than any other revenue law upon the statute books of this state or any other state so far as my information goes.

I have not written this article for the purpose of trying to influence any state toward any particular policy or method in the expenditure of its motor license fees or for the purpose of urging any state to adopt the plan which we are using in Illinois. My sole object is to call attention to the well known fact that conditions in the several states differ, and to make a plea for the permission of each state, knowing its own conditions, knowing its own people, to use those fees as the judgment of the residents of the state may determine without outside interference.

If the State of New York or the State of Michigan or any other state requires all of the funds derived from motor license fees for maintenance there can be no objection; on the other hand if the State of Alabama or Georgia or any other state wishes to use its motor license fees for road construction by a bond issue or otherwise that is their affair. The real test is not whether the money comes from motor license fees or general taxes; but how it is expended. If we spend it wisely and honestly the people will furnish it unstintingly.

CO-OPERATION WITH HIGHWAY CONTRACTORS IN WYOMING

A fine spirit of co-operation with road contractors is being manifested by the State Highway Department of Wyoming. Mr. D. S. McCalman, Superintendent of the Wyoming Highway Department, sent a New Year's letter to all employes of the department, from which the following paragraphs are quoted:

"Every contractor, as soon as he is awarded a contract by the State Highway Commission, should be considered a unit in our State Highway Department organization. Many engineers in charge of construction work are inclined to stand antagonistic to contractors doing work, and possibly some members of our engineering department have in the past taken this attitude. They are now, however, instructed that contractors doing work for the Wyoming State Highway Department are to be considered a unit in the organization, and they are to endeavor at all times and in every way to help complete the work promptly, economically and in accordance with plans and specifications.

"The phrase, 'according to plans,' is not, however, to be a hard and fast rule, and contractors should not hesitate to take up with district engineers any change in plans considered advisable.

"Regardless of the date set by contract for completing the work, it is most desirable from every point of view that you do your work as promptly as you can so that travel on the road will be inconvenienced for the shortest possible time, and that the people putting their money in the improvement may get return on their investment at earliest possible moment.

"All contractors were recently requested to furnish this department certain information we desire to file in the shape of card index, so that in awarding contracts we may give due consideration to past performance and financial responsibility, as well as the unit prices bid. In this connection contractors will be required on future awards to show they have a cash working capital in the amount of 20% of the total contract.

"Effective at once, contracts will be drawn so that contractors will be allowed on monthly estimates the value of materials delivered in advance of time required with a view to expediting the work. Also contractors will be allowed on monthly estimates the premium paid for surety bond as evidenced by receipt for same.

"It is my desire that this department do everything we consistently can to co-operate to fullest possible extent with contractors, and suggestions to this end will be appreciated."

MAKING PAYMENTS ON ROAD CONSTRUCTION CONTRACTS

By C. Coykendall, Engineer of Road Management, Iowa State Highway Commission, Ames, Iowa

Partial Payments

Partial payments on road contract work should be made at regular intervals, once a month, and should be as liberal as is consistent with safeguarding the public's interests. The only object to be served in retained percentages on work completed is to insure that the state or county can at any time take over a contract and finish it within the contract price plus the retained percentage and thus avoid the necessity of recourse on the bond.

A further argument in favor of partial payments is that a liberal policy in this particular on the part of the public will enable the contractor to carry the job with less working capital than is otherwise necessary. A contractor's working capital is worth six to eight per cent., whereas public funds usually draw interest at the rate of two per cent.

Partial payments should also be made on materials delivered along the work or at railroad sidings being used in connection with the contract when such materials are properly stored to prevent deterioration until they can be incorporated into the work.

Partial payments should be made at regular intervals. Effort should be made to get the estimates to the contractors at the time when they are expecting to receive them. One of the unfortunate features of many of our state laws is that vouchers must pass through so many hands before the warrant can be issued, with delay and consequent irritation to the contractor as the usual result.

Basis of Payment

The basis on which payments are made should be such that the contractor is paid for everything he does and no more, and should also be such that the engineer in charge of the work can determine with the least trouble and the most accuracy the amount due the contractor.

The basis of payment recommended for various types of highway construction is as follows:

(a) Earth excavation. Payment should be made on the cubic yard measured in cut, with some provision for overhaul. Bids should be received on loose rock and solid

rock excavation as well as earth excavation, and provision should be made for a special classification when materials such as sand or cemented gravel are encountered which cannot properly be classed as loose or solid rock excavation and which are considerably more expensive to handle than ordinary earth excavation. This special classification can also be used in connection with wet cuts that are often encountered in heavy grading work. Our standard specifications for Iowa contain a provision on this special classification which we find very popular with contractors in that they are protected against adverse conditions which cannot be foreseen, and which we on the other hand find easily enough administered.

(b) Bridge and culvert work. It is recommended that bridges and culverts be bid upon on the basis of the completed job in accordance with the plans and specifications, with provision for bidding on extra concrete and less concrete, to take care of changes in plans which are found advisable upon construction. This method has been used with satisfactory results in Iowa for a number of years. Foundation piling under bridges is bid as an extra, readily to allow variation in lengths and spacing.

(c) Pavements. Basis of pavement for constructing pavements should be on the square yard unit, the price per square yard covering everything in connection with the pavement construction with the exception of the earth excavation which is paid for as suggested.

(d) Gravel road construction and sand-clay construction. This type of road construction should be paid for on the basis of cubic yards delivered on the road and spread and hauled. We do not advocate that any maintenance be required by the contractor on this type of roads. It is becoming generally conceded that roads of this type are no better than the maintenance they receive after construction, and it is therefore logical that the county or state should assume such maintenance as soon as material has been delivered on the road. Owing to variation of materials used in this kind of construction, it is impossible accurately to foretell the amount of maintenance work that will be required to place the road in usable condition. The contractor therefore does not know how to bid on this item.

Paying on Contracts Held over Winter

Provision should be made in the specifications for releasing all retained percentage on completed work when the entire contract has not been completed and goes on into the succeeding year. The same idea as outlined above under partial payments, that of retaining only a sufficient amount to make it possible to take over the work and complete it within the contract price, should cover.

Payments on Materials

This topic has been covered under the head of partial payments above. We are making provision under our specifications this year to pay estimates on all kinds of roadbuilding materials delivered when the amount on hand is in excess of the amount that can reasonably be expected to be incorporated within the work within the succeeding month.

In addition to the points above mentioned, emphasis was placed on the desirability of developing our contracts and specifications along the line of the public assuming, in so far as possible, a part of the risk which the contractor must include in his bid and which the public must pay whether such risks actually materialize or not. We are protecting contractors against increases in freight rates and we are seriously considering some provision for protecting contractors against delay on account of failure to receive materials. We realize that this is a difficult matter to administer and thus far have actually done nothing to put it into effect, but it is being given our serious consideration.

PROCEDURE IN THE CONSTRUCTION OF BITUMINOUS MACADAM ROADWAYS

By J. E. Pennybacker, Secretary The Asphalt Association; 25 West 43d Street, New York City

Bituminous macadam came into prominence as a modification of the time-honored water-bound macadam highway, through the substitution of a bituminous binder for the water and rock dust which bonded the old type macadam. The bituminous macadam type, because it retained all of the good points of the water-bound macadam and added the qualities of a well bonded and dustless surface,

VIEW OF ASPHALT MACADAM HIGHWAY, BUILT BY PENETRATION METHOD, ON PUTNAM PIKE, TOWN OF JOHNSTON, RHODE ISLAND, AFTER THREE YEARS' SERVICE.

at very little more cost, and because it could be constructed with a minimum of equipment, has appealed strongly to thrifty road builders and tax payers as a highly desirable type of pavement for country highways.

After some ten years of actual demonstration, there are today earnest advocates, and equally earnest critics, of this type of pavement, and each can point confidently to striking successes, and equally striking failures, respectively. To draw from successes and failures a knowledge of the underlying causes cannot fail to be helpful for if we duplicate the causes of success, and avoid the causes of failure, we may reasonably hope for a satisfactory pavement as the outcome.

First, let me emphasize, however, the fact that this type, like other types of surface, fails in many cases because of defective foundation and poorly drained subgrade. Such failures should be studied in connection with foundation and sub-grade and should not be confused with

the merits of the pavement itself. Bituminous macadam may be laid upon any type of foundation, and it requires first class drainage just as any other type of highway.

Excellent Examples in New England

Massachusetts, Connecticut and Rhode Island have excellent examples of bituminous macadam. The latter state has on its main trunk line highways, examples of this type, constructed in 1913, at an average cost of $1.09 per square yard and maintained at an average cost estimated by the Chief Engineer at less than $50 per mile per year. He states that in no case has maintenance cost over $100 per mile per year, while on one of the sections there has been absolutely no maintenance of the metal surface to date.

In view of such a service record, it is the part of common sense to seek an explanation firsthand rather than to build upon theory, however sound. Mr. Patterson, the Chief Engineer, points to no fundamental changes in the type of construction as originally designed, but emphasizes certain faults which he found it necessary to avoid and certain qualities which he sought to attain. Thus he pointed out as the fault most commonly noticeable in the bituminous macadam the waviness or corrugation of the wearing surface, and he ascribes five causes to which this is due, namely, (1) the use of asphalt of too high penetration; (2) excessive amounts of binder; (3) crushed stone of too small sizes in the wearing course; (4) soft stone in the wearing course and (5) inferior construction methods. That his conclusions were sound, the results he obtained have demonstrated.

Experience in New York State

Experience in New York State with the bituminous penetration type has covered a period of about ten years, during which about 3,000 miles have been constructed. Of this entire mileage only about 100 miles, or about3 1/3 per cent. have been resurfaced or reconstructed. Of about 730 miles built in 1911 and 1912, 6½ per cent. has been resurfaced or reconstructed. This shows that with an average age of seven years, only a little over 7 per cent. has been resurfaced or reconstructed. The maintenance costs during 1915, 1916 and 1917 averaged $464 per mile per year, including shoulder work.

Many of these roads were laid upon sub-grades which were not adequately drained, and most of them were built to sustain a traffic far lighter in weight and smaller in volume than they have actually been called upon to sustain.

Rhode Island Practice

Turning again to Rhode Island practice, I find that an asphalt having a penetration of from 90 to 100 is used in place of the softer asphalt. The binding application is made at the rate of 1¾ gal. per square yard of surface and the seal coat at the rate of between ¾ gal. and 1 gal. per square yard of surface, the quantities thus corresponding to the general practice of this type of surface.

Both Rhode Island and New York practice involves the use of crushed stone, in both the base course and the wearing course, of uniform sizes, passing a 2½-in. screen and retained upon a 1½-in. screen. The depth of the wearing surface is made 2½ ins. thick after compression.

While Rhode Island uses trap rock I would recommend that road building rock which have the qualities of hardness and toughness in sufficient degree to render them suitable for water-bound macadam, but which lack cementing quality may be used in this type; this latter quality, while essential in water-bound macadam, is not necessary where bituminous binder is used. Thus, granite, quartzite, hard sandstone and a good wearing quality of limestone, have been, and can be, used to advantage in this type of pavement. As a measure of suitability, it may be stated that in Brochure number 6 of The Asphalt Association, attention is called to the fact that specifications frequently require the rock to show French coefficient of wear of not less than 7 when subjected to the abrasion test.

The striking success of the Rhode Island highways and their ability to withstand disintegration to the extent shown by the New York highways afford justification for a claim that, with careful attention to drainage, adequate foundations, careful workmanship, and with the adoption of the specifications as to material and binder, which have already produced successful results, the bituminous macadam type is easily entitled to be considered as standard.

I shall not go into detail in the matter of construction methods, but would like to call your attention to Brochure Number 6 of The Asphalt Association entitled "ASPHALT MACADAM," which gives our conception of the best theory and practice now prevailing in connection with this type of highway surfacing. Briefly, we set forth in the brochure the following salient points:

Foundations

Broken stone foundations should seldom be less than 6 ins. thick, and for heavy traffic should run from 8 to 12 ins. in thickness. Old macadam serves as an excellent foundation but test holes should be dug at frequent intervals to ascertain the true thickness of the old material so as to strengthen the weak places. Old gravel roads are suitable for foundation, except that where the gravel carries a high percentage of clay it cannot be depended upon to support heavy loads during the early spring north of the frost line, or where the sub-grade is likely to be wet for a considerable period. It is recommended that where old brick, block and concrete pavements are used as foundation, small depressions should first be filled with hot or cold patch material. It is recommended that broken stone foundation be filled with screenings and made to approximate a finished macadam road as nearly as possible before laying the bituminous top course.

An interesting comment by Chief Engineer Patterson of Rhode Island on the foundation problem is, that while the bituminous surface ultimately is very nearly waterproof and has a tendency to keep the sub-soil dry, the capillarity of certain sub-soils is so marked as to make the waterproofing of the surface sometimes of little avail. In studying this characteristic of sub-soils, the engineers make very careful examinations of conditions during a winter thaw, followed by an examination in the early spring, when the sub-soil is well saturated and when the frost is completely out of the ground. The Rhode Island practice is to employ a stone fill, avoiding telford as well as crushed stone, for the foundation proper. The stone foundations are constructed ordinarily of field, wall or

ledge stone of sizes varying from 3 to 15 ins., and the foundations vary in thickness from 6 to 18 ins.

Asphalt Cement

Application of asphalt cement may be made with hand-pouring pots or mechanical distributors, but in either case it is of vital importance that it be uniformly applied at the proper rate per square yard. In fact uniformity in application is the first principle to be observed in bituminous macadam construction. Emphasis is made as to the necessity of sweeping from the surface of the foundation all excess dirt and fine material before laying the pavement.

Asphalt cement should be heated to a temperature between 275 and 350 degrees F. The importance of keeping within these limits is emphasized, because if the material is heated above the maximum named, the asphalt will harden and may be injured by coking and burning; if it is heated below the minimum named, proper penetration will be hindered or prevented and an excess will remain near the surface. The asphalt should be applied when the temperature is preferably not less than 60 degrees F.

The following table gives the penetration limits of asphalt cement as recommended by The Asphalt Association. The suggestion is made that where soft rock must be used, a relatively higher penetration asphalt than would otherwise be used is justified, the reason for this being, as the softer rock wears away, a tough mastic results:

	Temperature		
Traffic	Low	Moderate	High
Light	120-150	90-120	80-90
Moderate	90-120	90-120	80-90
Heavy	80-90	80-90	80-90

Size of Stone

While stone passing a 2-in. ring is recommended, the larger sizes, as used in the Rhode Island practice are suitable if the compacted thickness is over 2 ins. Stress is laid, however, upon the necessity for uniformity in sizes, as wide variation will result in spots which will prevent penetration of the bitumen. Attention is also called to the necessity for rolling the wearing course until there is a mechanical locking of the stone fragment, the fault is frequently one of under rolling instead of over rolling.

Construction Details

Particular caution is given to apply the bitumen only when the entire depth of stone in the wearing course is thoroughly dry, and it is also urged that care be taken to prevent traffic from causing ruts, bumps or depressions. Where it is necessary to maintain traffic during construction, it is essential to delay traffic, after pouring, until asphalt binder has cooled to air temperature.

Not all of our roads can be constructed of the so-called higher types, such as brick, cement, concrete, sheet asphalt and asphaltic concrete, and it is generally recognized that water-bound macadam is not suitable for motor traffic. As the difference in cost between water-bound macadam and bituminous macadam is not great, it would appear to be almost a duty that we devote such attention to this type as will insure its construction under the best possible conditions, so as to make highway funds go as far as possible. Its maximum results have been so satisfactory as to indicate that it may even compete with the so-called higher types. In these days of $40,000 a mile highways we must take stock and cut our garment according to the cloth or presently we may experience a reaction in public sentiment through disappointment by the great mass of people at failure to obtain a mileage of highways sufficient to meet their traffic needs.

Acknowledgment

The foregoing paper by Mr. Pennybacker was presented before the recent annual convention of the American Road Builders' Association.

HOUSING—THE ENGINEER'S JOB

By Louis L. Tribus, of Tribus & Massa, Consulting Engineers, 15 Park Row, New York City

(Editor's Note:—Tribus & Massa conducted, as "Project Engineers," with their Architect and Town Planning associates, the design and construction of the New London and Groton developments of the United States Housing Corporation.)

Houses, more houses and still more houses is the insatiable cry from all over the land. No longer the wooden box—shutterless, porchless, conveniencelessness—but homes with light, heat, bath, toilet, porches (plural, mind you); no mud or ash approaches, but every civic betterment required. For the human being with sympathy, former visits to workmen's residence districts of the great manufac-

VIEW SHOWING OVAL PARK AT HEAD OF MAIN ENTRANCE TO UNITED STATES HOUSING CORPORATION PROJECT AT NEW LONDON, CONN.

turing plants and mining regions brought a heartache, that the reports of large dividends earned only aggravated. Fortunately, in this land at least, that nightmare is rapidly passing out, and Christian brotherhood is becoming popular.

To eat, work, play and sleep are the four chief functions of human existence, but so closely correlated are they that neither one can long be continued without the other.

With the taking on of education, as usually implied by the word, and the acquisition of property, as seems to be desired by most bipeds of intelligence, comes increasing demands for creature comforts and even luxuries. To that end gregarious living seems essential, with all the train of problems that inevitably follow.

Housing and transportation become the two of greatest importance; the former, ranging from the tent and mud-hut to the skyscraping palatial apartment house; the latter covering the conveyance of all commodities of life, and

humanity itself, to and from their places of production, work and recreation.

To large degree the nature of employment determines the permanency of abode, as also the character of housing.

Extremes of financial ability must be catered to, but in general the hardest work is to serve families who possess but little, up to moderately comfortable means, for they cannot usually afford to own their own homes: The rich need only consider their own preferences, so scarcely become a factor in the community problem.

A large class, with somewhat roving disposition, desires to avoid local ties and fixed responsibilities, and thus prefers to rent abiding places even at a greater lifetime cost.

Unquestionably the ideal for healthful comfort is a separate house for each family, with sufficient surrounding land and clean, free air, away from the noise, dust and confusion of the busy city.

Inadequate transportation and time for it, however, largely prevents.

Almost countless have been the solutions attempted, with success largely dependent on viewpoint.

Bad Housing Practices

In Philadelphia and Baltimore enterprising builders emulated the example of British cities and built miles of small two-story brick houses, all looking alike except for the gold leaf number on the front door plate-glass window light.

In Brooklyn, that city of homes and churches, the miles of brick became three-story, brown stone, with occasionally a shade of variety of front, though usually the same deadly uniformity existed.

In the old city of New York a similar condition obtained, but, befitting its greater prestige, four stories rose on high, with rather more ornamentation and some occasional attempt at distinctive architecture.

Comment upon other cities might be of interest, but the same motive prevailed in all—to build many of a kind at one time and sell out to innocent purchasers as soon as possible. Occasionally a row would tumble down from criminally poor construction before sales could be effected.

Just to forestall that kind of thing have grown up the Building Inspection and Tenement House Departments in our larger cities, very essential to protect the ignorant and unsuspicious tenant and purchaser. Some of the large manufacturing concerns have, to their credit, be it said, done largely in providing suitable housing for operatives, recognizing that with contented minds and healthful bodies better and more work could be done and the great losses from frequent labor turnover be largely eliminated.

Cities as such, however, have generally neglected that phase of community development, though practically everything else has been undertaken with public funds. But there are one or two noteworthy exceptions which will soon provide object lessons to be followed or avoided as the outcome shall prove the action wise or foolish.

Influence of War on Housing

The World War put an end to house building in bulk, for capital could multiply its return in quick turnover investment, yet the demand for housing tremendously increased, for in spite of the millions of men drawn into the army and navy, other millions sought new regions to live in, to participate in the work of shipyards, munition plants and manufacturing army and navy stores, supplies and equipment in inconceivable variety.

One could scarcely blame private capital, for the legitimate profit on the one side might be 25 to 50 or even greater per cent, while real estate could not promise over 6 or 7 net, with an uncertain future.

Uncle Sam, however, developed a very kindly heart for the workmen, particularly for those who were a little noisy and insistent, granting not only raise after raise in wages, but organizing two great agencies for house building. One, a branch of the Emergency Fleet Corporation, built houses chiefly near the great shipyards; the other, the United States Housing Corporation, a subdivision of the Department of Labor, aimed to serve the more important manufacturing plants and governmental agencies.

Though the armistice put a practical end to the great work started, enough has been accomplished upon a high standard of development, though far too high a standard as to cost, to furnish a very excellent object lesson, which it is hoped may serve for years to come.

The efforts were chiefly confined to erecting detached and semi-detached houses, though occasionally apartments and even hotels were perpetrated.

Great barracks were erected in Washington, and, as all know, the War Department built huge cantonments for the army, but these were to serve for temporary needs only, while the houses are of permanent value.

Experts were drawn from all over the United States to give intensive study to the individual cases, and the experience of foreign industrial towns, as well as of the few at home, was requisitioned. Noteworthy was the scant remuneration offered and accepted as a public duty by the small army of engineers, town planners and architects and their allied semi-professional associates, who all worked day and night under tremendous pressure to accomplish the one end in view—to build houses for earliest moment occupancy.

As the United States Housing Corporation has published several reports and many articles have been written, no full description need be repeated, though a brief word as to methods may not be amiss.

Methods of United States Housing Corporation

We cite the organization as it covered the broadest activities.

It was formed, first as a bureau of the Department of Labor, but later incorporated in New York State, with all the stock held by the Government. A managing director with several associates served as the controlling and truly hard-working body, conducting the various functions of work centering in three great divisions—architectural, town planning and engineering. Less conspicuous but vitally important were the fiscal, legal, real estate, insurance and finally managing departments.

Every real estate man, every manufacturer who was making or proposed to make war goods, and every city politician, wanted a share in house construction for his own neighborhood. Petitions and letters by the thousand filtered through promptly prepared standardized screens, mostly dropping into generous sized waste baskets, but still many reached the investigating committees.

If demands seemed to be well backed by real need, a

special committee was sent to make a locality investigation and report back promptly to the directors, with estimates of workmen to be accommodated beyond the community's power to provide, the sum needed and the lands and transportation available.

If authorized as a project, three experts were appointed as the "design committee" and the real estate purchasers got busy.

Until construction contracts were entered into, generally upon a cost and fixed profit basis, the design committee, architect, town planner and engineer served as a "board," each working out his own details, but all cooperating in general survey, design, plan and specification, and with remarkably little lost motion.

When a contract was awarded covering the whole work as planned, a works superintendent became the corporation's direct representative in charge, but the committee continued to function as individuals, however, in advisory capacity, though to the engineer was assigned the laying out of all work and supervising the whole, except, perhaps, the actual erecting of the houses. He also conducted, in large measure, negotiations with city officials and utility corporations.

As a rule the projects constituted the development of a new section of a town or city, so that few great problems were involved, as good taste and practical service dictated conformity to the communities' own standards. Still much latitude was allowable in house design and placing.

The more prosaic yet all essential engineering features could not vary much when providing sewers, gas and water mains, light distribution, pavements, curbing, gutters, sidewalks, trees, hedges, shrubs, etc.

Standard Plans

One of the most important and interesting features of the whole work was the remarkable standardizing of utility plans and, to some extent, that of types of houses, yet to each committee of designers was given a large latitude, within limits of cost and suitablity to climate and soil.

Taking the New London and Groton projects (having been immediately within the author's purview) as a sample, some four types of frame houses were adopted, yet by slight rearrangements ten different appearances were given, while the main construction details were alike.

Very exact bills of materials were prepared and large detail plans made, so that the saw mills, erected on the properties, could cut practically every piece of wood needed to size and shape and in wholesale quantity.

Each type of house was listed as needing so many pieces of each kind; these were labeled and bunched at the mill and carried to the building sites for the so-called carpenters to nail in place, the required pieces being handed to them by attendants, who received them from the distributors in logical order.

What wonder if a house could be framed in a day and be boarded in in three, the concrete or rubble foundations being sometimes placed simultaneously, though usually in advance.

Plumbing, cut and largely fitted in the shop, needed little but assembling in the house, and thus through all elements of construction.

All this contributed to speed, and to just as good or better work, than in the time-honored system of individual fitting, cutting and joining, but it of course required intelligent planning and exact mill work, with well-timed distribution and balance of erecting forces.

VIEWS OF UNITED STATES HOUSING CORPORATION PROJECT AT NEW LONDON, CONN.

Left: Main entrance to project, Lincoln Ave., 80 Ft. wide with parked centre. Brick pavement on concrete foundation. Right: Street intersection, bituminous macadam pavement. Concrete sidewalks, curbs, gutters and inlet basins to storm sewers. Wall of Oval Park in centre of view.

While all patriotically welcomed the armistice, many novel operations were nipped before reaching their full value, either for direct results or as object lessons.

The New London Project

The New London site was a typical Connecticut stony pasture area, with some swampy conditions; soil from clay to gravel, light and open, with a very generous distribution of boulders and some ledge rock.

Deep laid open-joint tile underdrains, leading into storm water sewers, relieved the swampy conditions: 8 in. sanitary sewers conducted the house flow to the city's main system.

Standard cast iron water mains with hydrants gave domestic supply and fire protection. Lead services from mains to property lines discounted an early tearing up of streets. Gas supplied all houses with fuel for hot water and cooking; coal furnaces provided for heating; electricity through wires on short poles on back property lines furnished light, and the poles also carried the necessary but exasperating telephone circuits.

Shrubs and vines, turf and seeding, with barberry front hedges and trees along the streets, added the touches of completeness, not often found in housing developments, yet enhancing sales values much more than the original cost.

Good concrete sidewalks, monolithic concrete curbs and gutters and asphaltic macadam pavements rendered their respective services.

Wire-cut lug Hillside brick on 6 in. concrete foundations were used for the heavier gradients.

A charming oval parklet, suited to Fourth of July orations, etc., and a parked center to the main entrance street, gave evidence of thought to the esthetic as well as to the practical.

The two-family houses have well separated individual entrances, and fairly sound-tight fire walls divide the two structures, so to considerable extent the advantages of single homes have been secured. Individual utility services were provided and abundant property goes with each half building to render divided ownership, as well as occupancy, satisfactory.

The time may come, however, when Mrs. Jones will want her house painted purple and Mrs. Smith hers an orange red, but long before that day the Housing Corporation anticipates through sales to be free from further responsibility. Perhaps city ordinances may then be needed to control the harmony of color, as well as tempers.

Engineering Costs on Housing Developments

In the issue of Feb. 5, 1920, the Engineering News-Record published an interesting letter from the present engineer-manager of the United States Housing Corporation, giving some facts, in part answer to certain ex-parte and very unfair criticisms by a Senate investigating committee. The following concerning engineering costs of the 24 completed projects may well be quoted:

"The first column is the percentage of engineering costs for engineering service on utilities alone; the second column is the percentage of all engineering costs to the value of all work performed by engineers.

"The percentage of fees overhead for the engineer or engineering firm was less than 1 per cent. of the cost of the utilities."

Project	Utilities Per Cent. (1)	Total—All Engineering Costs Per Cent. (2)
Aberdeen, Md.	6.537	10.89
Alliance, Ohio	10.80	18.00
Bath, Me.	4.23	7.05
Bethlehem, Pa.	1.248	2.08
Bridgeport, Conn. (a)	6.6	11.00
Bridgeport, Conn. (b)	7.2	12.00
Charleston, W. Va.	7.2	12.00
Erie (East), Pa.	4.02	6.7
Erie (West), Pa.	3.114	5.19
Indian Head, Md.	2.4	4.00
Mare Island, Cal.	3.936	6.56
New Brunswick, N. J.	3.048	5.08
New London, Conn.	3.18	5.3
Newport, R. I.	2.028	3.38
Niagara Falls, N. Y.	3.39	5.65
Cradock, Va.	4.98	8.3
Truxton, Va.	4.38	7.3
Philadelphia, Pa.	0.0665	0.1094
Quincy, Mass.	2.616	4.36
Rock Island, Ill.	5.274	8.79
Moline, Ill.	3.054	5.09
Davenport, Ia.	2.268	3.78
Waterbury, Conn.	2.994	4.89
Watertown, N. Y.	3.33	5.55

A few illustrations from the New London project may be taken as fairly typical of the results generally secured in these noteworthy developments.

Some War Time Lessons Applicable to Peace Times

What the financial side may have been has but little weight, for the conditions were those of "war," not "peace." Contractors learned a lot, and skilled labor may well, too, absorb the lesson that need for the niceties of experience is fast passing, so that when normal demand and supply bring their equalities once more, as prevail they will, those who now demand unreasonable return will be dropped into the discard.

Good workmen will always be needed and wanted, but only those who will give the equivalent in value of service rendered for the fat pay envelope to which they will then be entitled.

One of the conditions, disgraceful to labor classes as a whole, has been the unreasonable demands made and under stress granted for pay far beyond the worth of the work done.

The sizes of houses should naturally vary, but five or six rooms of moderate size and bath, with a good light cellar and a ventilated attic or air space, will probably fill the average requirements. The plans should be such, however, that an extra room or two could be added later without marring either symmetry or convenient use of the original part.

Materials used for such housing work are usually of but local importance, but to insure successful projects they must be mixed with good brains.

The public has had a chance to learn that tasteful design and attractive settings may be accompanied with economy of material and labor, provided intelligent forethought prevails, with combined judgment of architect, engineer, builder and financier.

The other great controlling factor in housing projects, granted of course the demand for houses, is that of transportation, and upon its solution will depend very largely in any given locality the success or failure of the enterprise in meeting the need for *homes* for working classes, not simply abiding places.

Access to schools, churches, places of amusement, shops, etc., must be easy and cheap, as well as to take the minimum of time between home and working place.

For the best of health these homes must be out of the congested portion of cities, but with good roads, extension of cheap transportation, provision of all utilities, etc. There is no good reason why the cramped city tenement may not almost disappear, except in the larger cities; a result devoutly to be wished.

If, however, one of the war lessons is well learned, working bipeds will be more and more considered as human beings, with instincts and ambitions very much like other people, and there is really some hope of that accomplishment.

Individual property owners cannot do much; it will take organized capital or great corporations or even cities to solve the problem effectively on a large scale. With the city planning so popular these days it is but a step further in socialistic activity to carry out the plans and actually build up cottage districts, not with the idea of becoming the permanent landlord, but to give the advantage to would-be property owners of mass construction on well considered lines.

To the engineer comes more and more the responsibility for civic adjustments; to his broad understanding of economic problems and his practical application of sound principles, the public is learning to look for guidance. His is the balancing decision between capital and labor; his integrity is trusted, albeit somewhat feared, by the politicians.

Without in any way belittling the splendid united ef-

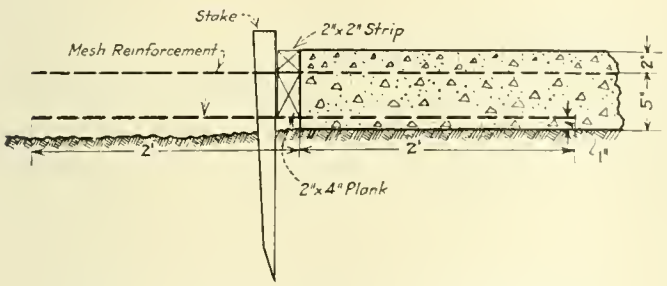
forts of others, the engineer won the World War, and it is to his grasp of the great work of reconstruction and reorganization that policies of right must be adapted and the lessons learned at such great cost be applied to meet the needs of the thousands crying houses, more houses and still more houses.

SOME DETAILS OF CONCRETE PAVEMENT CONSTRUCTION IN LAKEWOOD, OHIO

By E. A. Fisher, City Engineer, Lakewood, Ohio

The City of Lakewood, Ohio, has constructed a few streets of two course reinforced concrete. The base course is 5 ins. of concrete 1:2½:4, on this is placed reinforcing metal weighing 42 lbs. per 100 sq. ft. and a 2-in. wearing course of granite concrete 1:1½:2½. The curb is monolithic, built with 4½-in. radius where the curb joins the pavement. This is to save automobile tires and to improve the appearance of the street.

Transverse expansion joints ¼ in. thick were placed 36 ft. apart in clay streets and 50 ft. apart in sand streets. It was found that the action of expansion and contraction was no respecter of expansion joints but that some slabs cracked between joints and while there was sufficient



DETAIL OF NIGHT JOINT FOR REINFORCED CONCRETE PAVEMENT WITHOUT TRANSVERSE EXPANSION JOINTS, LAKEWOOD, OHIO.

metal to prevent the serious opening up of these cracks the question of the added expense of installing expansion joints was discussed and it was concluded to omit them. This was done. In the newer pavements transverse cracks have developed but are no more serious than those in streets where expansion joints are used. The omission has simplified the work of getting a smooth continuous surface and has improved the appearance of the street and really given a better pavement.

When the change was made the matter of a night joint demanded attention and was solved as shown by the sketch.

A vertical joint was left at night by placing a 2x4-in. plank across the street underneath which protruded a 4-ft. section of reinforcing wire mesh, 2 ft. beyond this plank the other 2 ft. being imbedded in the last batch of concrete laid. The upper reinforcement was also allowed to protrude about 2 ft. To secure the granite concrete wearing surface, a 2x2-in. strip was placed across the street on top of the upper reinforcement and both pieces of wood securely staked.

On the following morning the planks were removed, the old concrete was carefully cleaned and dusted with neat cement and fresh concrete carefully placed against the old work and the day's work continued.

We found later that a very fine hair crack followed this joint but this double reinforcement prevented it opening up.

The success of this method has lead to the abandonment of transverse expansion joints for city streets. It is conceivable that in long highways it would be necessary to put in liberal expansion joints at every change of direction, i. e., at the point of curve and point of tangent of both horizontal and vertical curves and at long intervals on long tangents. It is probably better to provide a place for expansion to get in its destructive work and watch it, than to have it occur at numerous and un-predetermined places. No one thinks of placing transverse expansion joints in monolithic brick pavements, and why in monolithic concrete pavements?

OPERATING EXPERIENCES WITH IMHOFF SEWAGE TANKS

By W. G. Kirchoffer, Sanitary and Hydraulic Engineer, 22 N. Carroll St., Madison, Wis.

About ten years ago when it was announced in the engineering journals that Dr. Imhoff of Essen, Germany, had designed and patented a new type of sewage digestion tank that had proved efficient, the news was enthusiastically received by most all of the sanitary engineers of this country.

Very soon Imhoff, or two story tanks, as they were sometimes called, became very popular as a means of the first stage in the treatment of raw sewage. I, like many other engineers, based my faith on the printed words of Dr. Imhoff and his colleagues and launched forth to adopt the new scheme as a cure-all for the shortcomings of the old septic tank.

Tank Fails With Creamery Waste

The first use I made of the Imhoff tank was for the waste from a small creamery. The design looked so promising to the State Board of Health of Wisconsin, that they published a bulletin on the use of this type of tank for creameries and gave general instructions for its design and installation. It soon developed, however, that this design was not adapted for this sort of waste, as nearly all of the solids came to the surface instead of settling to the lower chamber. In fact the tank would work better with the flow directed into the lower chamber and allow the scum to collect on the upper one.

Three Municipal Tanks

Just about that time I was called upon to design three or more sewage tanks for municipalities so that there was no opportunity to install one and watch its operation and form an opinion as to its feasibility before designing the others.

My first tanks were installed at Elkhorn, Waupun and Whitewater, Wis. All of these had concrete covers as the city officials were opposed to open tanks and did not want to go to the expense of housing them. The designs were based on the illustrations and data

given in the engineering journals and catalogs of Dr. Imhoff's agents in this country.

These designs were submitted to the agent of Dr. Imhoff for his approval which was granted without modification. It, therefore, could not be said that a proper design had not been carried out.

Trouble in Drawing off Sludge

Several plants had been completed before trouble began. Detailed instructions were given to the operators of each tank as to drawing off sludge and scum, cleaning sludge beds, etc. Our first troubles were noted at the city of Waupun where we found that it was next to impossible to get any sludge to pass off through the sludge pipe onto the sludge bed. Black putrescible liquid would come, but nothing else. After several attempts the city officials got disheartened and quit the job.

In the next few designs I attempted to correct this difficulty by leaving off the concrete cover and making the sludge pipe large in diameter, straight and as short as possible. Tanks were constructed at Mt. Horeb, Monticello, Denmark and Waukesha, Wis., incorporating the above suggestions.

However, the difficulty still continued, sludge would persist in accumulating on the surface of the upper chamber, with little or none coming out of the sludge pipe. If the period between attempts at drawing off sludge was several months, the pipe would appear to be clogged.

At Waukesha the difficulty was somewhat remedied by skimming the scum off every two weeks and pumping the sludge (black liquid) from the lower story each month. The effluent from all of these plants was never very clear, it was always of a milky color, and would soon become putrescible if allowed to accumulate along the banks of the streams into which it was discharged.

Modifications in Design

At the Southern Home for Feeble Minded, Union Grove, Wis., the design was again modified by using a sludge well or chimney which extended from the bottom of the tank to the surface and from which a 10 in. horizontal sludge pipe was laid to the sludge bed. The plant was slow in being constructed (convict labor) so in the meantime other experiences were had before its completion. The city of Ripon has had a sewage treatment plant for about 20 years, consisting of a coarse horizontal screen located over a small detritus pit and three sand filters of about one acre in total area. The average daily flow was estimated at 345,000 gals. per day. This plant had given fairly good results for many years, but in the last few years the capacity was not sufficient. The sewage at Ripon is a typical domestic sewage with a small amount of woolen mill waste and creamery waste.

It was sought to increase the capacity of the filters by removing a greater percentage of the settleable solids by the construction of a treatment tank. Although the Imhoff tanks previously constructed had not given the best of satisfaction, it was thought that these difficulties could be largely overcome by modifying the construction of details. That is to say, it was assumed that the principle on which the Imhoff tank was supposed to operate, was correct, but that the difficulties lay principally in the manner of construction and possibly some neglect on the part of the operators.

This plant was designed along somewhat different lines than any of those previously designed by me or those that I had seen elsewhere. To avoid the somewhat complicated construction necessary to reverse the flow periodically, the sewage was delivered to the tank at the middle of one side of the tank by means of a large shallow trough with a narrow slot in the bottom of the same. The flow through the upper chamber was to take place in both directions around the tank and pass from the tank on the opposite side in a similar trough. The tank was provided with two sludge wells, and two pipes and one gas vent. This design gave a relatively large surface to the upper chamber with a comparatively small space above the sludge chamber as was common in the earlier designs. The plant was put in operation in the early part of December, 1918, and one attempt to draw off sludge was made before cold weather set in. This was fairly successful from the standpoint of operation, but, of course, the sludge was not thoroughly digested by this time.

A sectional wooden cover was placed over the tank and it was allowed to operate without interruption until spring (about April 1st), when the covers were removed and an inspection made. It was found that there was sludge and scum on the surface of the upper tank to a depth of 3 ft. or more. Sludge had also risen into the sludge wells and gas vent to an unknown depth. An attempt was made to draw off sludge from the lower chamber but none came to amount to anything, only black liquid as had also been found in all of the other tanks. In a day or so the gas vent began to foam and run over into the upper story. The operator then attempted to clean the tank and took 976 wheelbarrows full of sludge from the surface of the upper story. The filter beds were not taking the effluent, but were clogging badly and when allowed to dry out, a thick leathery deposit was found on the surface of the beds. I made an inspection of the plant, and although 976 wheelbarrows-full of sludge had been removed there still remained 12 to 18 ins. of floating sludge on the surface of the upper chamber and in the gas vent. In the upper part of the lower story the sludge was 16 ft. or more thick.

All of my previous remedies for Imhoff tank difficulties had apparently failed.

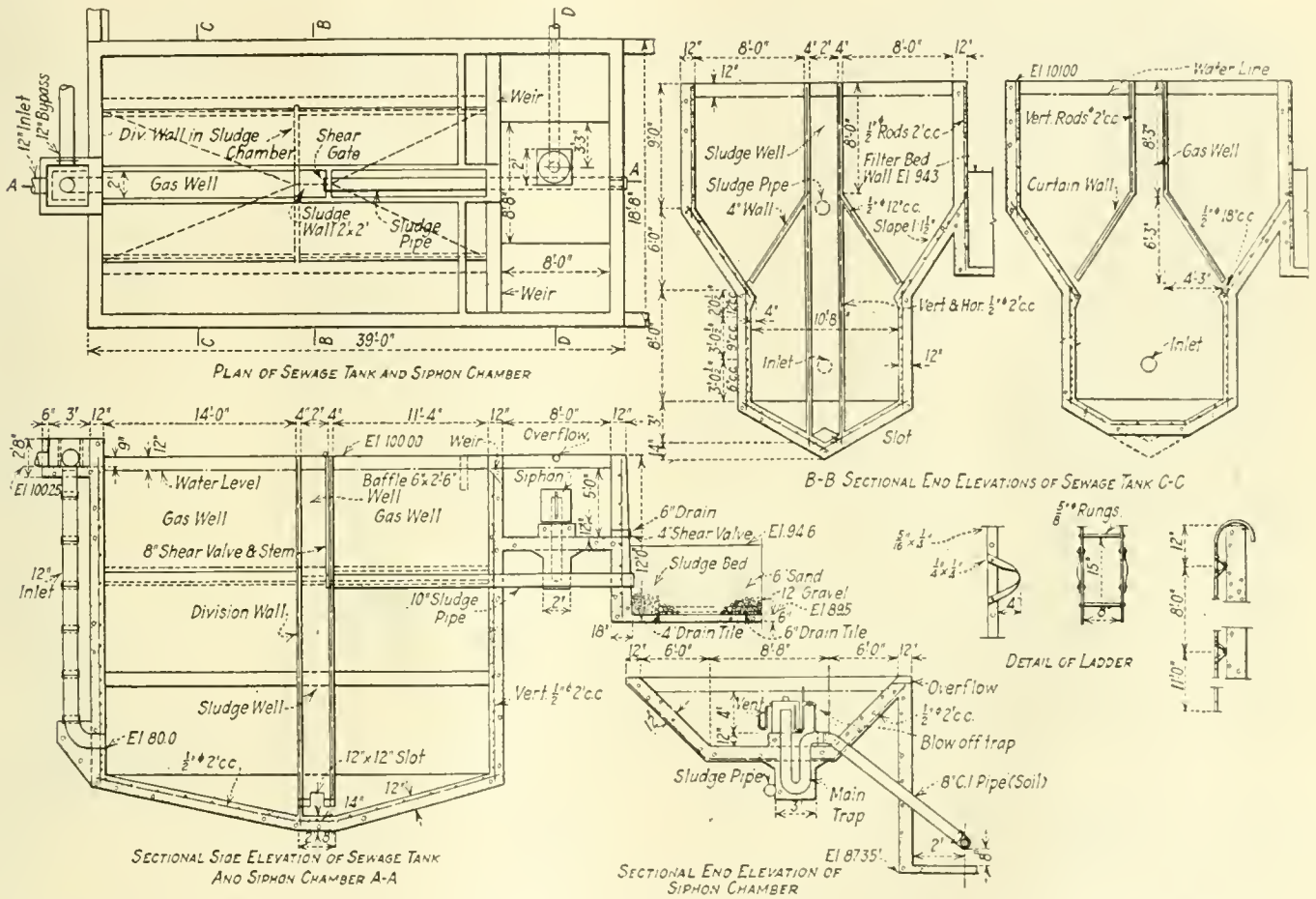
Raw Sewage Discharged Into Lower Story of Tank

To show why I now took the course I did, I must go back about a year to the winter of 1917-18 which I spent in Florida. While there I designed and built a sewage treatment plant for my winter home. This tank was designed similar to an Imhoff tank, but I did just what was contrary to the very principle which Imhoff laid down for the patent. I discharged the raw sewage into the lower story of the tank and contrary to all theory this tank gave most excellent results. The effluent was clear and readily absorbed in the under-

ground filter which I had provided. I have had this design in mind for a considerable time but did not like to experiment on others so did it on myself.

Upon my return to Wisconsin, I modified the design of the tank at the Southern Wisconsin Home for Feeble-Minded, which had not been completed, so as to direct the raw sewage into the lower story or sludge chamber. I placed a crosswall in this chamber so that the flow had to take place upward through the slots into the upper chamber, thence longitudinally through the upper chamber to the outlet. Any settleable solids brought up with the sewage could settle out and close the slots in the bottom of the inlet trough and cut an opening so as to allow the raw sewage to enter the gas vent. This he did very quickly and in three or four days the sludge in the gas vent and over the surface of the upper story began to disappear. The gas vent, although converted into an inlet, still acts as a gas vent, but more so than under the former method of operation.

The filters began to show signs of working more freely and inside of two weeks the sludge at the top of the tank was reduced to a layer of 3 to 4 ins. thick. On opening the sludge valves, large quantities of



DETAILS OF SEWAGE DISPOSAL PLANT AT VIROQUA, WIS., SHOWING INLET INTO LOWER COMPARTMENT.

slide down into the second compartment of the sludge chamber.

The tank, after being in operation for about three months, was inspected and the effluent was found to be clear but with a very slight odor. There was no scum on the upper story or in the gas vent. The sludge valve was opened and a small quantity of sludge came freely, which was followed by black water. This plant has continued to give good results ever since it was started.

A similar tank has been constructed and recently put in operation for the village of Union Grove, near by.

Returning again to the consideration of the troubles at Ripon, I could not very well reconstruct this tank so as to make it like this one at the Southern Wisconsin Home without a good deal of delay and expense. I, therefore, instructed the city engineer to sludge were discharged on to the beds. This dried quite readily and was not objectionable to handle. The leather-like mat on the filter did not form, and they operated better than they ever had on fresh sewage. The plant has continued to operate satisfactorily to the present time.

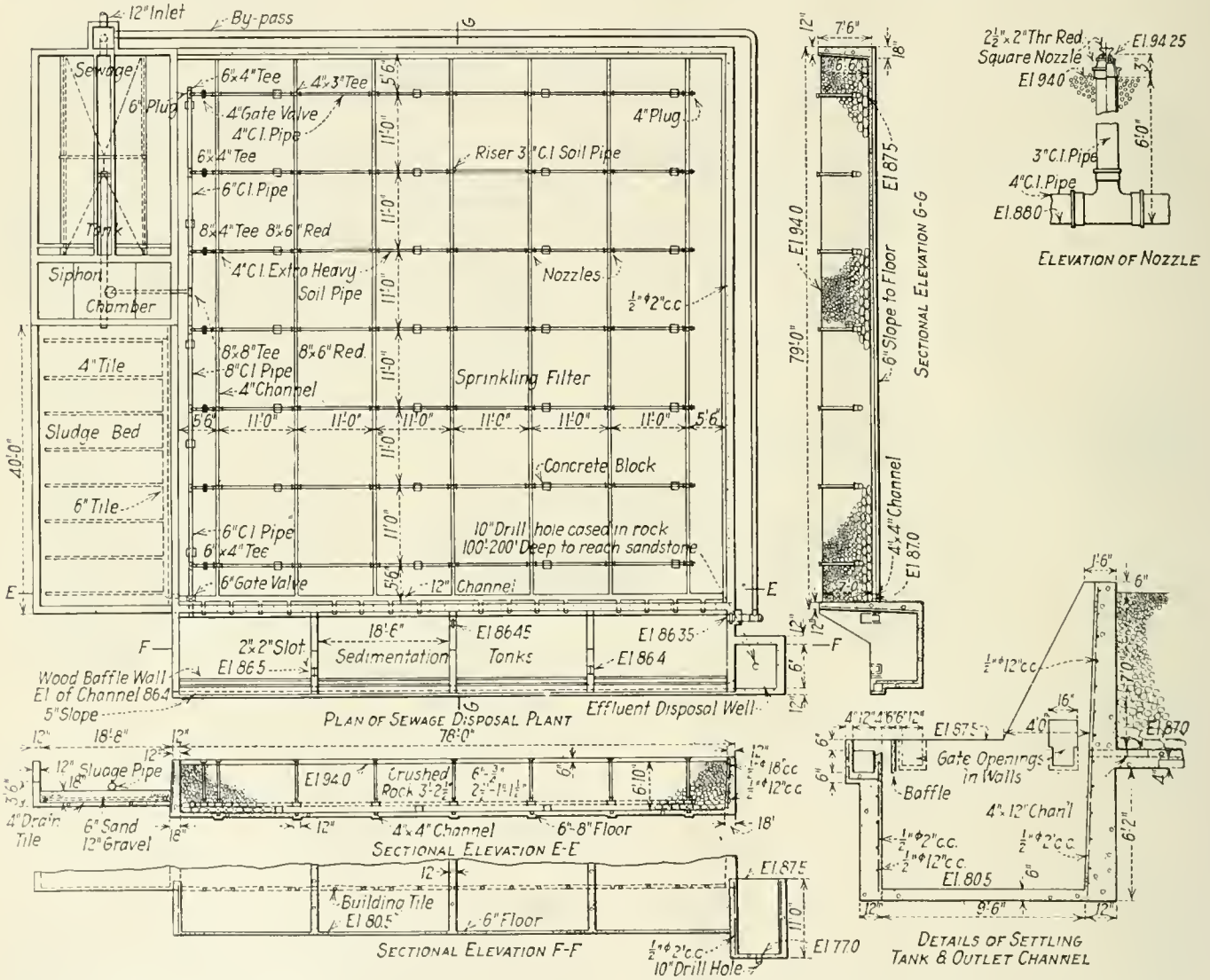
No chemical analyses of the effluent of any of these plants were made so that any conclusions to be drawn from this experience must be based on operating results.

At Lake Geneva, Wisc., a chemist had recommended the construction of an Imhoff tank and the officials of the State Board of Health were about to indorse it. Mr. Skeels, city engineer, is a personal friend of mine so he called me in consultation. I advised against the Imhoff tank and took Mr. Skeels and the Mayor to the Southern Wisconsin Home and showed them the new type of tank. They were finally convinced that

the new type was preferable and a plant was designed by Mr. Skeels which is very similar to the plant at the Southern Wisconsin Home. He writes me that it is giving satisfactory results.

The operating results of the plants of earlier designs still continue to be as bad as ever. The only one working at all satisfactorily is at Elkhorn. Even here the effluent has a stronger odor than that of the modified tanks.

I will not attempt to discuss in this paper the chemical and biological changes that must take place in much more readily digested by discharging the raw sewage into the sludge chamber than into the sedimentation chamber, and that foaming of the gas vents is prevented. The Imhoff tank was supposed to separate the solids from the liquids and pass them to the bottom of the tank for digestion. Why not put them there at the start and let the liquid rise and flow out rather than attempt to settle the solids? Many of these solids contain oil and grease which will float more readily than sink. Those that do settle soon become charged with gas and rise again to the surface where



DETAILS OF SEWAGE DISPOSAL PLANT AT VIROQUA, WIS., SHOWING SEDIMENTATION TANK AT END OF SPRINKLING FILTER AND THE DISPOSAL OF EFFLUENT BY PERCOLATION INTO DRY DRILL HOLE.

tanks of this design. It is quite evident that whatever they are, the operating results are much more satisfactory than they were with the regular Imhoff design.

In these examples at least, it is shown that the effluent although it may be more putrescible than from a properly operated Imhoff tank, is handled by the filters more readily than the effluent from the plain Imhoff tank.

Recommends Discharging Raw Sewage Into Sludge Chamber

These experiences have taught that sludge can be they often remain. Imhoff tank designs may be applicable to the conditions in Germany where there may be only slight amounts of grease and oils present or where the sewage is very stale, but according to my experience they are not adapted to the conditions in Wisconsin, where the sewage is fresh and contains greasy matters.

The foregoing paper by Mr. Kirchoffer was presented at the 1920 annual meeting of the Illinois Society of Engineers.

HIGHWAY ENGINEERING AS A CAREER

By A. N. Johnson, Consulting Highway Engineer, Portland Cement Association, 111 West Washington Street, Chicago

The primary object of this address is to interest engineers in highway engineering as a career. It will be my purpose to review briefly some of the underlying causes which make possible careers in highway engineering: to present some statistics which, whether they are already known to you or not, I believe will have a new interest and significance when studied as to their relation to highway engineering. I shall also present an outline of a few of the problems involved and some of the research work that is being done toward their solution and a resume of the magnitude of highway improvements to be undertaken.

Traffic Changes

The wonderful change in the character of our highway traffic is a matter of common observation to all of us, a change which has taken place within but a very few years. While in 1900 there were not to exceed 10,000 automobiles in the United States we have in 1919 upward of 7,000,000. When we consider that over 87% of all the motor vehicles in the world are in the United States it is easy to realize why the highway problem has become peculiarly of prime importance in this country. There are in the United States one motor vehicle to 16 inhabitants, or 2½ cars per mile of road; in New Jersey 11.1 cars per mile of road, in Rhode Island 16.2, in Massachusetts 10.4. In all Europe in 1917, by the last available figures, there were 437,558 motor vehicles; in France 96,000, in Germany 75,000, in Great Britain 150,000, or a total in these three great countries of but 321,000, while in 1918 in New York there were 459,292, in Ohio 412,775, in California 407,761, in Pennsylvania 394,186, and in Illinois 389,620; in each of those states a greater number than in all three of the great countries of Europe. There are 20 states in which the number of motor vehicles exceeds the number in France. There is little cause, therefore, to wonder at the wonderful interest in highway improvements in most parts of the United States.

Motor vehicles now produce a revenue which, for the most part, is devoted to road improvements, amounting to about $50,000,000 a year. On the basis that each motor vehicle travels on an average of 8,000 miles a year, and allowing an average of two horses to each horse-drawn vehicle, with an average of 600 miles a year, it will be found that our highways are used today as compared with 20 years ago about nine times as much, which is probably a very conservative estimate.

Road Administrative Units Larger

It has been found that our methods of administrating road funds that prevailed 15 or 20 years ago are totally inadequate to produce the highways that today's traffic requires. The administrative unit, the townships and small counties, was too small; it was a neighborhood affair and the officials had neither capacity nor funds at their disposal to build the road systems and character of roads necessary to accommodate the public. We have seen develop, during this period, state highway departments in every state in the Union. It is not necessary here to trace the development of the work done by these departments more than to say that broadly the tendency is wholly toward the construction of a state system of roads, built and maintained primarily at state expense. A number of states have, in a large measure, already completed York, Maryland, California, while Illinois, Pennsylvania, Michigan, Wisconsin, Delaware and some other states are actively engaged in building such systems. Bond issues have been voted or are being considered in very many other states for similar purposs.

Large Sums Available for Highway Work

We gain some idea of the magnitude of the highway building to be undertaken in this country when it is considered that there was authorized during 1919 for expenditure upon highways over $542,000,000. This total includes county as well as state bond issues for road work and includes in some cases bond issues voted in the fall of 1918. The amounts in some of the states are as follows:

Illinois	$69,000,000
California	59,000,000
Michigan	52,000,000
Pennsylvania	72,000,000
Texas	80,000,000
Ohio	85,000,000

In addition there are pending bond issues to be voted upon amounting to approximately $735,000,000.

In a recent circular issued by the Bureau of Public Roads it was shown that the actual cash in hand to be expended on road work in 1920 summarized as follows:

Brought forward unfinished work 1919	$165,000,000
Funds available for state and county taxes, Federal aid	273,000,000
One-fifth of recent bond issues now available.	100,000,000
Available from new bond issues to be voted on for 1919 and spring of 1920, together with unexpended balances of old bond issues	100,000,000
Total	$638,000,000

The largest sum that has ever been spent for improved roads in this country was in 1916, when approximately $136,000,000 was expended, and in 1919 about $138,000,000, so that it is seen the program for 1920 is four to five times as much as ever before undertaken, which means four to five times as much work, four to five times as much material, four to five times as many engineers, shipping facilities, labor supplies and contractors' organizations.

Some of the Problems Involved

The character of the roads that are to be built has, because of the necessity of changed traffic requirements, become much more expensive, although the first state roads built in Massachusetts cost from $8,000 to $10,000 per mile, many of them built for $5,000 and $6,000, we see today the average cost ranging from $35,000 to $50,000 per mile. As the requirements of modern traffic increase the necessity for more expensively constructed roads, in even greater ratio the responsibility of the highway en-

gineer increases and his field of usefulness enlarges and becomes of increasing value to the public.

As engineers you can sense the fact that there are many problems connected with the development of our highways that press for solution. Whether it is a reflection or not upon highway engineers now in service, it is a fact that there are no precise data by which today we can design a road. We do not even know the loads and resulting stresses that modern traffic imposes upon our pavements. It is only within the past year that the United States Bureau of Public Roads has undertaken to ascertain exactly just what happens due to the passage of a loaded truck over a road surface, but it is gratifying to know that there is today under way a series of tests to determine these data and already some remarkable facts have been developed.

Another line of investigation of utmost importance in the design of our road systems is to ascertain the operating cost of our highways; that is, what does it cost to operate motor vehicles over our highways under varying conditions of grades and of surfaces? We know in general that over certain stretches of road we use much more gasoline than over others; that more power is consumed and that the operating cost is greater.

A series of tests was conducted by the writer to investigate the relative fuel cost over different types of road surfaces, all of which were more or less improved. The result of these tests showed that, while over an earth road in fair condition a gallon of gasoline drove the trucks 5.78 miles, over hard, smooth concrete surface the distance was 11.78, an increase of six miles more per gallon; that is, the difference in traction resistance between an earth road surface in fair condition and a hard, unyielding surface was one-half the amount of fuel consumed on the former.

On a largely used road, the number of vehicles known, the fuel consumption can be closely estimated and requires no stretch of imagination to appreciate that on this item alone (gasoline) there would be warranted a very large investment to improve the surface to lessen tractional resistance. We have no information as to the cost of operating over grades, do not know today how much more we would be warranted in expending to reduce a given grade so far as it affects the cost of operating upon the highway. Operating cost, when it is ascertained, will unquestionably be found to be the chief element of expense, but it is not today considered in highway design. Because this expense does not come out of the public treasury, but is contributed individually in small amounts by each of us who uses the highway, makes it no less a real item of cost that should be taken into consideration.

Demand for Highway Engineers

With the increasing amount of work to be done, the organizations of all state highway departments must be enlarged, and this is making greater demand for capable engineers. Universities and engineering schools should be made aware of the shortage of men trained for highway work. Young engineers should have brought to their attention the opportunity that lies open and they should keep in touch with highway work and be encouraged to apply their technical training to highway problems.

Highway Engineers' Salaries Should Be Increased

In closing I want to touch upon one activity that is very close to all of us; that is, salaries paid to engineers, particularly salaries paid engineers in state highway service. These engineers, as is the case with nearly all engineers in public service, together with engineering faculties, are today woefully underpaid. There has been an association formed known as the American Association of Engineers, not a technical organization, but formed to promote the welfare of the engineers.

This association had compiled a recommendation for salaries for engineers in railroad service which has been submitted to the various railroad administrations and has proved a real help and assistance in revising the salaries of engineers in this service. Recently a committee of this society has prepared a similar recommendation for salaries for engineers in state highway service, and I have little doubt that the publicity that will be given these recommendations will go far toward making them effective. According to these recommendations, rodmen and chainmen, young men just out of college, are to receive $1,200 to $1,500, with the expectation within a short time that this amount would be raised. Engineers who are in highway service from two to three years should reasonably expect to receive $1,800 to $2,400. Positions requiring five or six years' experience, acting as first assistant engineers in various divisions, to receive $3,600 to $5,000; division engineers or district engineers of a state, $5,000 to $8,000, and state highway engineers, $8,000 to $15,000.

Some have questioned the sanity of the public to vote such large sums for highway projects, but there is no evidence to show that the projects are larger than are required or than will be used. Our sanity is to be questioned not because of our determination to build the roads that we need, but as to the means that may be employed to spend these large sums. It would be insane to entrust these expenditures to incompetent hands. It rests with you and other men of education and understanding to see that a sane intent does not become an insane realization.

The field of highway engineering offers many chances for useful and satisfying careers. The field is constantly enlarging and offers larger inducements than ever before.

Acknowledgment

[The foregoing address by Mr. Johnson was presented before the recent annual meeting of the Ohio Engineering Society.]

CONSTRUCTING ROADS FOR MOTOR TRUCK TRAFFIC

By T. R. Agg, Professor of Highway Engineering, Iowa State College, Ames, Iowa

In a broad sense, the construction of roads for motor truck traffic involves the adopting of types of improved surfaces, based on appropriate economic considerations, financing by methods that will distribute the costs in an equitable manner and accomplishing the actual construction in accordance with accepted practice in high engineering, so far as practice has be-

come standard, and blazing the trail wherever research and experience indicates the possibility of improved methods.

Economic Considerations

Economic considerations of great complexity are involved in the selection of the type of improvement best suited for motor truck roads, but economics too often play no part in the selection. There propably are settled convictions in the minds of many engineers and there certainly are in the minds of many laymen, as to the best type of surface for the highway that is to be used by the motor truck. But accurate data bearing on the subject are almost entirely lacking in the records of American highway engineering. The cost of transport on surfaces of various types has not been determined in a scientific manner, taking into account time, fuel costs and costs of vehicle maintenance. The cost for fuel on each of the more common types of surface is known to vary materially, but exact figures have been determined in a comparatively few cases. These considerations would be determining factors in those instances where the prices of several types of surface were nearly the same.

Cost of Maintaining Road Surfaces

Of greater importance than cost of maintenance of vehicle is the cost of maintenance of the roadway surface, or more properly, the annual cost of the roadway surface during its useful life. A study of the records of initial cost of road surfaces and of the cost of maintenance and the useful life of the surface, leads one into a maze of conflicting figures. Each set of data is vouched for by those responsible for its promulgation, and yet all can not be given equal weight. There must be accumulated a comprehensive record of these costs, based on uniform methods of accounting and reporting throughout the United States and accompanied by careful records of tonnage of traffic, before the engineer will have at hand sufficient data for the selection of the most economical type of roadway surface. Some State Highway Departments have made a start on such tabulations but the records are, as yet, too few to be of much use to the engineer.

Sane Financing

The financing of extensive surfacing projects involves very large sums of money and conditions during the past few years have been favorable to highway financing so that comparatively little difficulty is experienced in obtaining money for road improvement. Looking to the future, however, it must be apparent that the completion of the projects now in contemplation in the United States will involve such enormous sums of money that a foundation of sane financing must be laid at the earliest possible moment. This is particularly true now that it is so generally recognized that an appreciable percentage of the highways of the nation must be constructed of such a character that they will be adequate for motor transport, of both high speed passenger vehicles and slower speed heavy freight vehicles. Construction of this character is costly, although the cost is probably far below the actual benefit to the communities traversed.

Assessing Costs According to Benefits

It may be within the province of this paper to mention briefly some factors that can properly be considered to have a bearing on the determination of a rational system of financing state wide highway improvements.

It is believed that a system of financing that is in a general way based on distribution of cost according to benefits is justifiable and will be proof against claims of unjust discrimination in taxation for road improvement. The almost insurmountable difficulty lies in devising a means for determining where the benefits fall or the extent of the benefit in any direction.

Community Benefit

Probably no one questions that an area that is liberally served with railroad facilities derives therefrom a community benefit that may seem to be somewhat intangible yet is nevertheless real. The benefit becomes apparent when such a community is compared with one not so favored. In the same way, the construction in any community of adequate highways of year-round serviceability for motor transport, confers a real benefit on that community. A part of the cost of such improvement might, therefore, properly and equitably be paid from general taxation in the district served. But the possibility of the district profitably utilizing the facility will vary greatly with the nature of the industries in the district and it is doubtful if any fixed percentage to be assessed as a general tax would be equitable for an area even as large as a state. Differences in assessed valuation of land would, however, tend to equalize taxation to a great extent even though the rate of taxation is uniform.

Benefit to Agricultural Lands

There is also a direct and tangible benefit conferred on agricultural land by the construction of improved roads contiguous thereto. Lands on good roads are worth more than those not so situated and will actually sell more readily and at a higher price. The land can actually be made to show better profits when located on a good road than when not so located, because of the greater facility with which it can be operated. Therefore, a certain part of the cost of durable improvements can rationally and fairly be assessed against such lands. The percentage of the cost to be so assessed is not easily determined, but certainly should not in many cases exceed twenty-five per cent of the total cost.

Benefit to Users of Highways

It probably will be admitted that the most apparent and tangible benefit from road improvement accrues to those who actually travel the highways for business or pleasure and since about 95 per cent of the tonnage on the nation's highways is made of various classes of motor vehicles, it follows that to them the benefit of improved roads is most apparent. The cost for fuel, for vehicle upkeep and the saving in time on improved roads are real and measurable benefits. Some tests of a preliminary nature were made at Ames to determine the difference in gasoline consumption on various types of surface. While these were too few in

number to be conclusive, they indicated twenty per cent as the possible saving between an average earth or gravel road and a high class paved surface. This would mean a saving on motor operation in Iowa of upwards of three million dollars a year. It is equitable to require the owner of motor vehicles to contribute somewhat to the cost of the improvement of the highways and very largely to the cost of maintenance. This has been recognized in recent legislation in several states.

The amount that is added to the cost of a road because it must accommodate motor truck traffic can hardly be taxed against other than owners of motor trucks and it would seem probable that in the future both trucks and passenger vehicles will be required to bear an increasing portion of the cost of road construction and maintenance.

In the whole problem of highway finance, it is necessary to recognize that a roadway is being provided as a transportation facility that is not operated for direct income and the incentive to keep accurate account of the use of the facility in order to place the cost where the benefit is realized is lacking. Nevertheless, the great highway system desired by all progressive citizens can never be fully completed and maintained unless the financing is placed on a sound economic basis.

Engineer Lacks Data

In the design of highways for motor transport the engineer is confronted with a problem for which he lacks some of the fundamental data for a complete solution. To begin with, he cannot predict with any assurance the size or weight of the vehicle for which he must provide, yet it is essential to an adequate design to know the maximum load for which provisions must be made. It is for that reason that steps are being taken, looking toward legal standards for the size and weight of motor vehicles.

Neither does the engineer know a great deal about the supporting power of soils under road slabs or the structural strength of road slabs of various designs. In these matters experience affords some guide to the establishment of the proper design, but refinements of design that would lower the first cost, are entirely within the range of possibility. In this field some investigations of great value have been completed, but much additional information is greatly needed.

In the field of railway engineering the relation between grade and curvature of the line and the cost of operation is fully established and when the tonnage of traffic is known, the justifiable expenditures for lowering grades or eliminating curvature can be computed. In the highway field no such data have as yet been obtained and the design of grades and alignment of highways for motor transport is necessarily based on unsubstantiated assumptions.

Highway Research

It may be permissable to digress from the subject long enough to call attention to the recent organization by the Division of Engineering of the National Research Council of a National Program of Highway Research. The establishment of a scientific basis for highway design is a prerequisite to the economical expenditure of the funds necessary to provide an adequate national highway system. The step taken by the National Research Council will, if properly supported, supply the needed data and every organization desiring to advance the highway movement should lend support to the Research Council in carrying out the ambitious program upon which it has embarked.

Trend in Highway Design

Notwithstanding the handicaps under which highway engineers have worked in the matter of fundamental data, relative to the construction of road surfaces for motor transport, very great progress has been made during the past five years. It may be pertinent to point out the trend in design at the present time.

Widths—The standard double track width has been increased from 14 ft., the common width a few years ago, to 18 or 20 ft. The allowance per line of traffic has been increased from 8 ft. to 9 ft. The width provisions have become more liberal in that almost no single track roads are being considered for the main routes of travel and near populous centers, many sections of three track road have been built.

Alignment—Recognition is being given to the desirability of furnishing direct routes and shortening distances wherever possible. Pleasure traffic is not so much benefitted by this as is business traffic. On busy routes a saving of a mile in traveled distance between towns, represents in a year a very appreciable saving in time and in operating cost for the vehicle.

Safety—Safety considerations have also entered into the design to a marked degree and dangerous sections of road are being eliminated by relocations or by extensive grading. The elimination of short radius curves and the superelevation of the paved surface on the curve are additional safety precautions that are being generally adopted. A great many railway grade crossings are being eliminated and where that is impossible, suitable warning signs are being posted. Guard rails for protection on fills are standard for main highways.

Surfacing—The lessons of the past few years relative to the disastrous results that follow covering up poorly drained subgrade have been unmistakable. It seems now to be recognized that even a rigid pavement cannot give maximum serviceability when placed on a poorly prepared earth subgrade. The trend is therefore toward much more extensive and costly drainage work preliminary to the surfacing, but it is believed that money so expended adds very materially to the useful life of the wearing surface and is a justifiable expenditure.

Heavy Slabs—In addition to the added care in the preparation of the earth foundation, heavier road slabs are being employed in many states and it is believed that this tendency is in the right direction. Wherever it is likely that truck traffic will develop, and apparently that is wherever roads are provided that will accommodate truck traffic, the accumulated experience of the past five years points clearly to the ultimate economy of heavy slabs.

Smooth Surfaces—Increasing attention is being paid

to securing surfaces that are smooth, with a view to minimizing the effect of the impact of heavy loads. If the road surface is even slightly uneven disastrous pounding occurs when the truck travels at normal speed. This is a cause of rapid deterioration to both truck and road surface. As time passes it may be expected that the speed of freight vehicles will increase and while pnuematic tires will do a great deal to minimize impact, every reasonable precaution must be taken to secure smoothness of wearing surface.

Maintenance—A very general recognition is being given to the necessity for effective maintenance. No matter how admirable may have been the construction, a road surface subjected to motor truck traffic will not give a maximum of serviceability unless systematic and timely maintenance is provided. It will bear constant reiteration that nowhere is the old adage "A stitch in time saves nine," more applicable than in highway maintenance. Patrol systems and the gang method have been developed to a high state of efficiency and the high degree of serviceability of a new road is maintained without marked depreciation for long periods of time. Timely maintenance if carried out persistently for a period of years probably costs less than spasmodic efforts to make repairs at irregular intervals and certainly continuous maintenance results in the greatest average serviceability.

The foregoing is from the paper by Professor Agg, presented at the 1920 annual convention of the National highway Traffic Association.

SURFACE TREATMENTS ON MACADAM AND GRAVEL

By Philip P. Sharples, Manager, General Tarvia Dept., The Barrett Co., 17 Battery Place, New York City

The advancing cost of paving has made questions of salvaging existing road structures of great importance. Paving costs have doubled for the cheaper types of road surfacing, but for the more expensive types the costs have trebled. On top of this interest rates are advancing so that looked at from an economic point of view the road engineer is justified in expending very considerable sums per annum to salvage old pavements.

Forty thousand dollars per mile for a new pavement 18 ft. wide is a conservative estimate for a pavement that formerly cost $15,000. Interest on this at 5% is $2,000 per year; depreciation for a life of 20 years, $2,000 per year. The maintenance on top of this would make the total $4,500 per year per mile, that could profitably be spent on an old pavement, provided it could be made to carry the traffic to the satisfaction of the public.

Salvaging Old Pavements

Surface treatments with bituminous materials form a ready means for salvaging many types of pavement. Although only the treatment of macadam and gravel will be gone into in detail, it must not be forgotten that methods have been worked out for satisfactorily surface treating bituminous concrete, bituminous macadam, wood block, Portland cement concrete, and even under certain condition of sheet asphalt and brick paving.

The knell of the macadam road has been sounded say some of the advocates of high-priced pavements, but the conservative engineer will still find in his scheme of paving a place for plain macadam while he will be careful so to draw his specifications that surface treatments of bituminous materials may be applied effectively to the macadam. Macadam well built on good foundations when protected with surface treatments can still be relied upon to carry goodly numbers of vehicles.

Some Causes of Resurfacing Failures

Much of the dissatisfaction with surface treatments on macadam roads has arisen not through any fault of the system but on account of the attempt to salvage pavements that have gone so far that they could not be retrieved by so simple a method, or where they were subjected to traffic that called for a heavier duty type of pavement. It was the engineer's judgment that was at fault, not the method. It would be just as logical to condemn a dwelling house floor because it gave way when the dwelling was used for the storage of pig metal.

BREAKING UP SURFACE TREATED FOR A NUMBER OF YEARS WITH COLD REFINED TAR AT YORK, MAINE, WITH BUFFALO-PITTS SCARIFIER.

The choice of the bitumen too has often been at fault. Dust-laying oils and raw tars have been confused with the more permanent refined tars and asphalts which alone will be considered here. Dust-layers simply weight the dust particles and prevent their blowing about. The heavier bitumens prevent dust by binding and protecting the road surface, either by penetration into the road crust or by forming protective mats of bitumen and stone upon the surface.

Many of the old macadam pavements have worn thin or have ground up internally under traffic weights that they were not designed to carry. Obviously in theory, but seldom in practice, these old road crusts should be strengthened and drainage errors corrected before successful surface treatments can be expected. With soft rocks it may even be necessary to strengthen the crust by employing some of the modified penetration methods, using the thinner tar or cut back asphalts applied cold as practiced in Maryland and Wisconsin.

Where new macadam is built, it should be so constructed that surface treatments can be successfully ap-

plied soon after or even before the road is opened to traffic. The old tenets of good macadam construction are too well understood to dwell upon here. Suffice it to say that drainage and foundations should be good, that the design should be equal to the loads that are to be imposed, that the road should be built of good materials, properly rolled and properly filled and bonded.

The Surface

The surface must be given particular study. It must be remembered that the final surface proposed is a bituminous surface. The contour should be therefore not that of a macadam road but that of a bituminous road. A camber of one-fourth to three-eighths of an inch is plenty. A greater crown than this makes a slippery road.

The material for the surface course should be carefully chosen. The stone should be as large as can be made to bond in place. For a soft stone, sizes grading from 3-in. down to 1¼-in. are not too large. With trap rocks and hard stone, ¾ to 2-in. may not be too small, if the pieces of different sizes are well graded.

The kind and amount of bonding material are of great importance. Usually stone chips and stone dust of the same material as the stone used give the best results, but with soft limestones, a graded clean gravel from ¾-in. down to ⅛-in. often gives superior results if intelligently used. The aim should be thoroughly to fill the voids in the stone by flushing in the filler with alternate watering and rolling until the surface is solid.

Extreme care should be observed to leave no layer or cake of screenings on top of the stone composing the surface. If any such layer remains it is often impossible to surface treat the road successfully.

Clay and materials that produce slime should be religiously avoided in the top course as they form emulsions with bitumens and the coating sloughs off.

The ageing of the macadam before it receives the bituminous treatment has of late years been the subject of much study. With the heavy mat coats, it is important that the macadam be thoroughly set up by aging before the application is made. The cementing value of the rocks used, the traffic and moisture conditions, are factors in the setting up process. Usually, six weeks to two months in the spring and summer are sufficient. Pavements finished in the fall may be carried through the winter by using calcium chloride, and then the bituminous treatment given as early as practicable in the spring.

If cut-back bitumens, applied cold, are used, it has been found possible greatly to shorten the aging before the application, and even if care is used, to apply the bitumens on completion of the road. With soft rocks, and rocks of low cementing value, new possibilities are indicated by these methods of early protection against automobile traffic.

The refined tars applied cold have given particularly satisfactory results in this field and even where subsequent treatments have been made with asphalts, the first use of tar applied cold has been found advantageous.

Whether a macadam road is old or new, it must be very thoroughly cleaned before surface treatments are applied. Brooming with steel wire rotary brooms followed by local hand work is good practice and care must be taken to clean the pavement down to clean stone. Caked material or dust on the surface prevents the bitumen from penetrating and from bonding onto the stone. Hot blanket coats require particularly thorough cleaning of the road. Sometimes a priming coat of cut-back bitumen applied cold helps in forming a bond.

The Bituminous Material

The choice of one bituminous material that can be used to solve all the surface treatment problems that arise is a manifest impossibility. The kind and grade of bitumen must be varied to suit the kind and the size of stone used in the road crust, to suit the expected volume and character of traffic and its distribution through the seasons, and to suit the climatic conditions, and in the face of all these variants, a choice of material and method is more often controlled by the funds available.

It pays to make a close study of local conditions and to get the benefit of the combined experience in any locality.

The amount and kind of cover for the bitumen offers just as interesting a field for study as the bituminous materials themselves. The choice is often limited to what is available locally, but given a variety to choose from, little chance of mistake is made in choosing the hardest material possible and in using the largest sized particles that will be held on the road by the bitumen. The amount used should be the least possible to protect the surface from picking up under traffic. It is better to add more subsequently than to use too much at first. A big excess wastes bitumen and may even destroy the coating by furnishing mineral aggregate in excess of the binding power of the bitumen.

Treatments of hot bitumens to be successful require good hard stone cover of the correct size. Unless this is used rolling and rutting are almost sure to occur. Stone as large as ¾ to 1¼-in. may sometimes be used to advantage.

As the cover and its application from a considerable part of the expense of surface treatment the economic cost factors should be thoroughly studied. Some bitumens require much more cover than others and some require more expensive cover. As this extra cost may be in part offset by greater durability, the problem should be viewed from every angle.

Re-Treatments

Re-treatments call for special study as the conditions are essentially different from the first treatment. Usually little sweeping is required and the patching is a much easier matter or may even be deferred until after the treatment is applied. As a rule the quantity of bitumen required for re-treatment is much less than for the original treatment. The road is already saturated with bitumen and a renewal and enlivening of the surface is generally all that is required. A macadam which absorbed a half gallon originally can usually be re-treated with a quarter gallon. In subsequent re-treatments the amount may be still further reduced to advantage. Thickening of the mat is in most cases to be avoided, as it leads to rolling and rutting of the surface. Sometimes the same end can be gained by using a thinner bituminous material applied very sparingly.

The care and maintenance of surface coatings requires careful thought to make it economical and effective. No surface treatment should ever be applied unless provision is made for taking care of the surface. The introduction of cold patching materials has made the care of surface treatments much easier. Much is gained by patching breaks and abrasions as soon as apparent. For this reason patrol maintenance is particularly effective in taking care of surface treatments. Equally good results may, however, be obtained by gang maintenance with automobile equipment provided recurrent trips are frequent.

VIEWS OF THE RETREATMENT OF MACADAM SURFACES.

Top Row Left: Disruption of newly constructed plain macadam under automobile traffic at Peterborough, New Hampshire. Proper surface treatments prevent this trouble. Right: Road surface reshaped ready for retreatment at York, Maine. Bottom Row: Retreating surface at Boston, Mass., with sprayer mounted on Packard truck—Road after scarifying and retreatment at York, Maine.

Surface Treatment of Gravel Roads

Surface treatment of gravel roads with anything more than dust-layers may be said to be more or less in the experimental state. The distinct successes measured in permanence to date have been on gravel roads that to all intents and purposes were macadam roads. In discussing the question, the term gravel must be distinctly defined. The term is applied to a great variety of materials of different sizes and mineral content.

In addition to variations in the material, gravel roads are built under widely varying specifications. No lasting surface treatments on a gravel road are possible unless the road as constructed is capable of sustaining the traffic that goes upon it. A surface treatment cannot supply drainage, a foundation, a base, or a thick bituminous wearing course. All that can be expected of it is to supply a protective coating that will conserve the surface from the abrasion of automobile traffic. Whether this coating is lasting or not depends wholely on the sustaining power of the structure.

Even if they are not lasting these treatments may be economically justified. Gravel roads in the northern states, when well built and properly maintained, are never out of condition more than one month of the year, and that is in the spring when heavy hauling of any kind is usually out of the question in these districts. The lumber hauling is done on the snow and the crops are moved in the fall when the gravel road is at its best. The better road is hardly justified economically in many situations and yet something must be done to hold these roads against automobile traffic.

If surface applications at a cost of $600 to $800 per year can take the place of an expenditure of $15,000 to $40,000 per mile, they certainly are economically justified since the yearly bill for interest, for amortization, for repair and renewal will be three to eight times the cost of surface treatments. The importance of intensive study and development in this field cannot be too much emphasized.

The untreated gravel roads of the glaciated states are of great economic importance since they may be built at

a comparatively low cost and will sustain light traffic successfully. Traffic censuses on roads of this class show that they will take care of about 200 automobiles per day with the ordinary gravel maintenance methods of dragging and patrol. Beyond this traffic, the surface becomes loose and the disintegration of the surface becomes serious. Dust-laying oils alleviate the dust nuisance, but the oil destroys the natural bond of the gravel and causes much potholing.

Maine and New Hampshire Practice

In Maine and New Hampshire a system has been worked out using cold refined tars that enable these roads to carry 2,000 to 3,000 automobiles per day through the summer season. For the winter and spring the road crusts may break up, but as the traffic on these roads at that time is extremely light, and not of a heavy loaded type, it militates little against the success of this type of road and the surface treatment.

For the first treatment the road is dragged into good condition in the spring, with addition of a new gravel, if necessary. Application of sufficient gravel to amount to more than 2 ins. should be made in the fall. After the road has dried out and hardened under traffic, it is swept with horse brooms and the first application of cold refined tar applied. This is allowed to soak in without cover. A second treatment is then given. This is left without cover for four to six hours of sunshine and then if any liquid remains on top, enough cover is used to blot up the excess.

Patrol maintenance is given these roads and is necessary to maintain them economically. All bank gravels run uneven, so that dust pockets exist in these roads which sooner or later break out. The breaks are easily repaired with tar and gravel, if attended to immediately, but if neglected, spread and threaten the whole road.

The roads may or may not break up in the spring, depending on the road and the weather. After hard winters, such as 1917-18 they do not break. After open winters like 1918-19 the road usually breaks when the frost is coming out of the ground. In case the road does not break, it is shaped up and dragged back into condition like an ordinary gravel road. In either case, a single retreatment of ¼ gal. per sq. yd. is usually sufficient to put the road in good shape for the season's traffic.

Reshaping Roads

If the road goes through several seasons without breaking up, it is usually necessary to break it artificially as the road through frost action and heavy traffic gradually loses its shape. A road roller with spikes in the wheels, a steam scarifier and a harrow are effective tools on this work. After the road is re-shaped, it is re-treated and maintained as before. However, as the gravel is stuck together in lumps, the road acts more like a macadam and will go a much longer period before it requires breaking a second time.

Experiments in the South

Similar experiments have been carried on in the south and southwest over a variety of gravels. Success has been dependent on the care taken in the selection and preparation of the original road and in the care taken with the treatments and their subsequent maintenance. These experiments have proved here as elsewhere the futility of surface treatments over gravel and similar materials without provision being made for constant and intelligent maintenance.

The absence of frost makes this treatment oftentimes in the south successful, where failure would be expected in the north. On the other hand, the high summer temperatures long continued, make it imperative to choose bitumens and methods which will eliminate as far as possible tendency to roll and rut. The refined tars of the cold application type, at least for the priming coat, have been most successful. For the finishing coat, bitumens heavy enough to apply hot have given good results, if a cover composed of hard rock and sized up to 1-in. has been used.

Surface treatments blend gradually into penetration work. It is hard to draw the distinction between a heavy surface treatment of hot bitumen, put on in two coatings, using large stone for cover and light resurfacing job by the layer method. From an engineering standpoint, the difference comes mainly in the end to be desired and the methods employed in doing the work. From a mental attitude, it is generally safer to figure on a real penetration job if heavy topping is aimed at, rather than to take the standpoint of a surface treatment.

Work of any description that leads to real economy in road work, to the saving of past investments and to the rectification of past errors is of the utmost importance at the present time. Engineers are so busy with new construction problems that they are prone to forget that present economic conditions are such that the salvage of an old pavement in an economic manner is almost more important than new construction. At present prices, it pays to save. If we lose sight of road economics in a wanton waste of public funds, there will be a day of reckoning. What is called for at the present time is economy and thrift in private and public work. No other course will lead us out of the present unstable conditions.

Acknowledgment

The foregoing paper by Mr. Sharples was presented at the recent annual convention of the American Road Builders' Association.

USE OF LABOR-SAVING DEVICES ON HIGHWAY CONSTRUCTION

By Richard Hopkins, Troy, N. Y.

Jobs where the excavation exceeds 5,000 yds. per mile, and where a large proportion of the hauls are long, will generally call for a steam shovel. Where hauls are short and cuts small scraper work will continue to hold first place. No grading job is complete without wheelers, drag scrapers, fresnos, and at least one road machine.

Each of the three types of scrapers is more economical than either of the others under certain conditions, and for the small extra investment in plant it is foolish to be without at least a few of each one of the three kinds. Most contractors have in the past erred on the side of having their wheelers too large and their drag scrapers too small. The fresno of a 4 ft. width is the proper size for the average job. In case of shovel breakdown the teams can be put on scrapers until the shovel is repaired.

The road scraper is the most maligned and the most neglected grading tool we have. A good operator is essential, and with one much good finishing work can be done cheaper with the grader than by any other method. There is a big range of sizes available, so it is an easy matter to choose the one best suited to the particular job.

It is advisable to carry rough grading and finished grading along together, as the latter can always be done more cheaply while the dirt is mellow. Specifications are growing more stringent in the matter of rolling in thin layers. This requires a big labor expense on the dump, especially with steam shovel work. A team on a 4 ft. fresno will take the place of six men on the dump and spread the dirt evenly for the roller. In this connection it is well to remember that aside from a steam roller nothing has been found that equals the compacting effect on a fill of horses tramping over it.

The rotary grader has been on the market only a short time, but large capacity and cheap costs have been reported. It works rapidly in loam or gravel, and cuts accurately to grade. It also cuts old macadam readily, and a stone screening attachment can be provided if a contractor desires to save the old crushed stone. The old-time rooter plow and scarifier are tools that will always be used when a small amount of old macadam is encountered. Most plow companies now make a heavy mold board plow with a narrow cut that is more successful in real hard pan than a rooter plow.

In shallow cutting with a steam shovel in old macadam it will generally be found best and cheapest to cut a few inches below grade and dump every third or fourth dipperful behind the shovel for the fine graders to bring the sub-grade back to the correct elevation. Where a roller is fitted with a scarifier attachment it is sometimes found that a lot of expensive hand work can be saved by its use. It is recommended that where the sub-grading machine or planer is used between concrete forms a steam roller be used to pull it. The roller is necessary for rolling the sub-grade, and its use in pulling the planer dispenses with the need of providing a traction engine.

Asphalt Roadway

When the first penetration work was done the bituminous material came on the job in wooden barrels, was heated in a small kettle and poured on the stone with a small hand pot. The great bulk of material at present arrives in tank cars and is heated by steam. Motor and horse-drawn distributors are now on the market that apply the hot bituminous material at a high and uniform pressure and thus get a good, even penetration. Auto truck distributors with a central station are now located in various parts of the country, and a number of these will make deliveries at as great a distance as forty miles from the central station. The last few years the use of low-pressure steam for heating has been largely discarded, and high-pressure steam is being used on all new installations. It is possible to use an old low-pressure boiler and put a small super-heater between the boiler and the tank car and get fully as good results as are gotten with a high-pressure boiler.

Concrete Roadway

Material Dumped on Sub-Grade—By this method there is an average loss of about 5% on material, and where all the materials are high priced this becomes a very appreciable item at the end of the job. Where material is kept a long way ahead of the mixer this material serves as a big stock pile placed where it is instantly available for the mixer. In these times of poor material deliveries this sub-grade method of storing finds many advocates because it enables the contractor to keep the mixer running. It is not a bad plan to have a few small stock piles of sand and stone scattered at various points along the edge of the road so that if the material at the mixer begins to run a little shy a small amount of sand or stone can be brought in with a one-horse cart to meet this deficiency. The biggest disadvantage of stocking stone and sand on the sub-grade is that materials are hauled through fresh grading, and after a heavy storm it is difficult or impossible to get through for a while. Also, after a heavy storm a motor truck loaded with material will have a churning effect upon the sub-grade. There are three methods of handling this material from the sub-grade to the mixer.

Wheelbarrow Method—With wheelbarrows materials should be placed correctly so as to avoid both long wheeling and short wheeling. Short wheeling always makes a crowded and cluttered condition at the mixer and interferes with progress. All wheeling should be done on wooden runways. The mixer loader is a long conveying belt actuated by a gasoline engine. Above the belt are small hoppers into which the men shovel the material from the sub-grade. This does away with the wheelbarrows, but not with the shovelers. One of these machines will save about five men. A self-propelling crane at the mixer will save about twelve men. With both the mixer loader and the crane the job is speeded up, and more batches per hour will be turned out than by the wheelbarrow method.

A movable bin at the mixer with a loading attachment has been suggested, but this is open to the criticism that material arriving at the bin in motor trucks must come in a fairly constant stream, as the capacity of a bin would be only a few batches, and any delay in the transportation would mean a delay at the mixer.

Batch Transfer—The batch transfer method saves from 75 to 80 per cent. of the men at the mixer. It is generally used in connection with industrial railway haulage, and each batch containing the proper amount of cement, sand and stone in a box or a car is hoisted and dumped directly into the mixer. There can be no argument that this method results in less loss of material, avoids cutting of sub-grades and allows more working days per month for concreting than any other method thus far tried. The original scheme of operating entirely by industrial truck requires a length of track equal to the distance from the unloading point to the farthest point of the job.

Recently a plan, modified as to haulage, has been advocated by some manufacturers and contractors. It involves the use of 6,000 to 8,000 lin. ft. of track with the necessary switches, cars and locomotives. The concrete mixer is started at the point nearest the unloading station, and approximately the first mile or mile and a half of the road is built by the industrial haulage method entirely. The portion of the track nearest the railroad station is then taken up and moved ahead and a temporary stock pile is made, or bins are set up at a point approximately 4,000 ft. away from the railroad station. Material is hauled to this point over the finished concrete road in motor trucks, and

is then transferred to the batch boxes on the industrial railroad, and from this point on the regular batch transfer method is followed. When another mile of road is completed the position of the bins or stock pile is moved ahead to the farthest point of the concrete road which has had the necessary minimum time for curing. The application of this method results in the following:

The industrial railway haul is very uniform; the number of men required on trains and track remain the same, and the flexible part of the hauling is in the number of motor trucks used. The motor trucks can always be hired; they can work long hours and the hauling cost per ton mile over finished concrete roads is low where there is only a small delay in time in loading and unloading.

The advocates of this method point out that while their costs include a second handling of material, their plant charges are very low compared with a regular system of industrial haulage. A contractor who has five miles of track to build five miles of road has half of his equipment idle when two and one-half miles of his road are completed, and 80 per cent. of his equipment idle when he has four miles of his road completed. This modified method possesses the same advantage as entire industrial haulage does in the matter of the grading, which is entirely away from the mixer and in no may interferes with it.

Central Mixing Plant—Industrial engineers who are in the habit of placing thousands of yards of concrete from a central mixing plant are continually asking why a central plant is not used more in building concrete roads. A haul of four miles by motor truck or industrial railway is possible before the concrete takes its initial set. Where water from a municipal supply is available and there is ample yard room at this unloading switch, a central mixing plant can be fed from overhead bins and a surprisingly low labor charge and plant charge per yard of concrete can be obtained.

Unloading Methods—Wherever it is possible to do so, a trestle should be used for unloading. Frequently an existing trestle can be rented for a nominal amount and extended, if not already of large enough capacity. The economy of a short trestle is very much greater where the railroad company provides frequent switching service. Where only one switch a day is provided a trestle might be of doubtful economy, while the same trestle with two or three switches a day would be a very profitable investment. Bucket elevators run by gasoline engine and delivering to overhead bins continue to be a popular method of unloading. They of course require double the switch room of any other method. With a short switch track frequent switching is a valuable help toward large daily capacity.

With both a bucket elevator and a trestle, battleship cars work better than any other type, and these are more easily obtained during the summer season than gondolas. A locomotive crane with a clam-shell bucket can be used for direct loading, loading into overhead bins, loading onto a storage pile or onto a stock pile above a tunnel.

Water Supply—In providing a water supply the essential requisites are continuous service, ample supply and good pressure. Dual pumping plants are the best insurance for a continuous service. Where there is a point of high elevation near the road a storage tank of 1,500 to 3,000 gals. capacity is also a big help. Ample supply and good pressure cannot be maintained with a small pipe line. Inch and a half pipe should be used only on short lines with a heavy gravity head. The 2 in. pipe line is in almost universal use and is satisfactory where the line does not exceed one mile in length.

Much better results on the average job will be obtained with a 2½ in. pipe line. Its use will become increasingly popular as construction men begin to appreciate how many of their pumping troubles disappear when this larger line is put in service. Where sources of supply are a long distance apart, booster pumps are necessary to provide good pressure.

In unloading bulk cement from a gondola car a clam shell can be used. In unloading bag cement two-wheeled hand carts will save one or two men.

Depreciation in Plant—Where a plant is assumed to have a life of five years, a great many people are charging off 20% yearly. A more correct way is to charge off about 40% the first year, 40% of the remainder the second year, 40% of the remainder the third year, and so on until the end of the five-year period.

Acknowledgment

[The foregoing matter is from the paper presented by Mr. Hopkins at the recent annual convention of the American Road Builders' Association.]

THE MUNICIPAL CONTRACTOR AND FREQUENT INCONSISTENCIES MET WITH IN SPECIFICATIONS

By Wm. C. Fraser, Civil Engineer and Contractor, 707 Germania Life Bldg., St. Paul, Minn.

The author of this paper served as City Engineer and Consulting Engineer for 15 years before he began to do contracting work, and some of the clauses of specifications quoted were prepared by the author while he was acting as a consulting engineer. I sometimes think that a consulting engineer should first act as a construction engineer or do contract work for himself before going into the business of consulting engineering, said Mr. Fraser in addressing the annual convention of the Minnesota Surveyors' and Engineers' Society.

Accurate and Complete Specifications

In preparing specifications the engineer should prepare them from actual measurements and surveys and know that the quantities given are correct; that the plans and specifications and estimates show everything that will be needed to complete the work. If this cannot be ascertained the specifications should so state and contain a cost plus percentage clause allowing extras for unforseen material and labor needed. The engineer should not expect the contractor to bid on the quantities given and shown on the plans and then guess at what additional work he may see fit to require before he accepts the contract.

Good Work Wanted

The engineer should not expect the contractor to comprehend what will be needed when he does not know himself and the proper way to cover the unforeseen is to have it classed as extra and paid for at cost plus a percentage

for use of tools, superintendence and profit. The engineer should take the time necessary properly to prepare the plans and specifications and see that he is properly paid for doing so, for where he guesses at the quantities of material needed and makes an incomplete survey, he only damages his own reputation and makes trouble for himself as well as the contractor. In the majority of cases the city councils wish to have the best kind of work done and are willing to pay for it and the engineer should see that they secure the best possible workmanship and material, and he is sure to have trouble if he does not so show and state in his plans and specifications.

The Responsible Contractor

A large majority of the contractors would rather do first-class work that is not only a monument to the engineer, but that will stand as a recommendation to the contractor. We all know that there are contractors who are only after the money that can be made out of the work and their only object is to get through with the contract, secure their money and let the engineer and City Council make the best of it. The engineer should see that contractors of that class are not allowed to secure any more work under their plans and specifications. This would encourage the contractor who is willing to do right by the engineer and in time there would be a better class of contractors bidding on work. It is almost impossible for a good contractor who wishes to do first-class work to compete with the contractor who cares nothing for his future standing and reputation.

Estimates of Cost

In submitting estimates, the engineer should know that they are reasonable and that the work can be done for the amount of his estimate. I have found by experience that in the majority of cases the engineer's estimates have been too small for the work contemplated and when it came to letting the contract they could not do so for the reason that the amount of bonds voted was only about two-thirds of the money needed to do the work required. So the work either had to be dropped altogether or reduced so as to come under the amount of money raised. This usually causes dissastisfaction among the residents and trouble for the City Council and a loss of faith in the ability of the engineer, while if the estimates are higher than the bids received the City Council and the citizens are pleased and instead of diminishing the work, which creates dissension and a damage to the plant, the work can be completed, or even extended, which might assist in satisfying some of the discontented citizens.

Calling for Bids

Before bids are asked the engineer should see that the plans are properly prepared, so that the City Council know just what they are going to have and how they are going to make payment for the work. Contractors should not be expected to bid on work and put up certified checks and agree to give a bond and sign contracts to do work, until they know the class of payments that are to be received and know that the payments will be made as called for in the contract and specifications. They should not be asked to go to the expense of attending lettings unless the City Council know that they can let the contract if bids are satisfactory.

When asking for bids the contractor should be required to deposit with his bid a certified check as a guarantee that he will enter into a contract if the work is awarded to him and the certified check should be for a lump sum so that he will know before leaving home the amount of check necessary.

Proposal Blanks

The engineer should prepare proposal blanks for the bidders so that all bids will be made on the same basis. The proposal blanks should call for a lump sum bid and also for additions and deductions so that the city may have the right to increase or decrease the amount of the contract. These proposal blanks should be made as short as possible, also the contract, and there is no reason why what is put in the specifications should also be repeated in the bidding blank and in the contract. The bidding blank and contract should both refer to the specifications and the specifications should cover every thing necessary to be done. One or two pages should be sufficient for the bidding blank or contract, and the specifications on the ordinary job should not cover more than 15 or 20 pages.

Contractors' Bonds

The bond should require sureties satisfactory to the City Council and should not state that it is necessary to furnish a surety bond, for in a good many cases a personal bond can be furnished which will save the city considerable money and would be more desirable than a surety bond. The present rate on bonds is 1½ per cent. In many cases this is only a waste of money as the contractor is personally liable and his own guarantee is sufficient to cover all the work that he has under consideration. Where he is able to secure good and reliable personal bonds he should be allowed to do so. By having the clause in this form the reliable contractor may be able to secure a surety bond if he so wishes at a better rate.

Progress Estimates

In giving progress estimates, the percentage should be as high as possible and the contractor should receive not less than 85 or 90 per cent. of the amount of material furnished and work completed the first of each month, and there is no reason why more than 10 or 15 per cent. should be kept back as all contracts in Minnesota must be guaranteed by a bond equal to the amount of the contract and when you have this bond, why should it be necessary to hold back an exorbitant amount on the payment of the work? This only curtails the amount of work the contractor is able to handle, makes it necessary for him to borrow more money on which he has to pay interest and eventually has to come out of the city.

Up until three years ago the author of this paper, in bidding on work, never figured anything in for the cost of his bond, employers or public liability, but the rates have become so high in the past few years, that if a contractor failed to add these three items to his bid he would soon be put out of business. As stated before it costs the contractor must add 1½ per cent. on the total contract from 2 to 2½ per cent. for public liability and from 4 to 10 per cent. for employer's liability, so that you see the contractor must add 1 1/3 per cent. on the total contract and not less than 10 to 12 per cent. on his payroll to cover these contingencies alone.

The following are a few clauses frequently found in

specifications that make contracting very uncertain and where the same are in the specifications it is necessary for the contractors to add additional price to their bids:

Clause 1—The contract price as above set forth shall be the whole compensation when paid, to first party by second party for the laying and construction of said work as set forth in the said resolutions, plans, profiles, specifications and proposal made by the first party whether or not there be as much or more, or less labor, material, excavation or rock cut or otherwise than is estimated by the City Engineer has no bearing on the above contract price and does not affect it.

Clause 2—The contractor assumes all risk of variance in any computation or statement of amounts or quantities necessary to complete the work required by this contract, by whomsoever made, and agrees to furnish all labor and material of every description and fully to complete the said work in accordance with the plans and specifications and to the satisfaction and to the satisfaction of the Common Council for the price bid.

Clause 3—The plans and specifications are intended as complete but should anything be omitted accidentally from the specifications, which is necessary to complete the work in accordance with the apparent intention of the engineer, it will be supplied by the contractor at no extra cost to the city.

Clause 4—All work not herein or on the plans specified but which may be fairly implied or understood as included in this contract and any apparatus or appliances essential to the proper and convenient operation of the plant shall be supplied and installed without extra charge by the contractor and the engineer or his authorized agent shall be the judge of this.

Clause 5—Any discrepancies in the plans and specifications shall be decided by using the best class of work or material which any interpretation would admit.

Clause 6—No claim for extra work or material shall be made or will be allowed except where ordered in writing and all such claims shall be presented monthly in writing within 15 days after the completion of said work.

Clause 7—Should any disagreement arise as to the true meaning of the drawings and specifications in any part, the decision of the engineer shall be final and conclusive.

From advice I have received from attorneys a contractor has the right to bid on the least quantities stated in the contract and specifications and contractors are entitled to rescind a contract with the municipality for the construction of contract work where the contract was made under a mutual mistake, according to the Massachusetts Supreme Court decision. "The estimates on which the contractors made their bid, made by an engineer employed by the municipality and given to the contractors by it as correct, materially underestimated the amount of work to be done, and it was held that the contractor was not bound by them, notwithstanding the estimates were given in good faith, their inaccuracy unknown until after the contractors had begun work, and notwithstanding the contractors expressly covenanted to do the work 'in strict accordance with the maps, drawings, profiles, and specifications prepared therefor, all of which were to be considered as part of the contract and to be construed therewith,' and 'that the amounts and quantities of materials and work as stated in the notice to bidders, governing the making of proposals, were approximate only.' "

Clause 8—No work will be allowed to be laid in water and all work must be kept free from water until cement is set.

Clause 9—The contractor shall, at his own expense pump or otherwise remove, any water which may exist in the trenches and shall form all dams or other work necessary to keep excavation clean of water during the progress of the work.

Clause 10—In no case shall the sewers be used as drains for water and the end of the sewer pipe shall be kept properly plugged during construction.

In place of the above would it not be better to state that where water is encountered it will be allowed to drain off through the sewers as they are being constructed under the direction and approval of the engineer, and that upon completion of the work the contractor must see that all sewers are clean and in good order? I have known of cases where it would be impossible to construct sewers unless the water was allowed to run through the sewers as laid. In general if the contractor undertakes to pump the water out of the sewer ahead of the sewer pipe, he only disturbs the original foundation and is more likely to leave a place where there would be a settlement of the sewer than if the water was allowed to run through and the sewer pipe laid in the trench without disturbing the foundation.

Clause 11—Although the engineer may specify certain methods for constructing work in difficult cases, this will not relieve the contractor of the responsibility.

If the engineer instructs the contractor how to do work and the specifications require that he follow the direction of the Engineer, why should this not relieve the contractor of the responsibility?

Clause 12—Where the material at the grade line appears not suitable for securing a firm and unyielding bearing, in the opinion of the engineer, the contractor shall excavate to such depth as he may be ordered to do below the pipe line and replace the excavated material with sand, gravel, timber or concrete; timber or concrete if used will be paid for extra.

Why should the contractor not be paid for the sand or gravel as well as timber or concrete if used? I have had cases where I have been required to furnish sand and gravel under this clause for which I did not receive pay, while the proper thing to use was concrete but it would have been necessary for them to pay me for the use of concrete and they required me to use the gravel.

Clause 14—Through marshy ground the excavation shall be carried at least 1 ft. below the grade line and lower if required in the opinion of the engineer and filled with sand and gravel.

If this is done, why should not the contractor be allowed an extra as it is an unforeseen item?

Clause 15—No bill will be allowed for material

left over on account of any of the above quantities being reduced during the progress of the work, nor will any extra be allowed for on account of any increase in above quantities.

If a contractor is required to sign a contract for a certain quantity of material and the material is left over, why should not the city be allowed to pay for this material, or on the other hand, if after a contractor has been awarded a contract and has ordered his material and the city makes additions and extensions, why should the contractor not receive an amount sufficient to make up for any additional costs in securing this material?

Clause 16—Where pipes are being laid the contractor shall leave uncovered from 20 to 50 ft. of pipe so that the engineer may be able to inspect and test the grades and lines before any backfilling is permissible.

I have found from experience that it is advisable to fill immediately over the pipe before the cement has set. I have been called on to inspect several jobs where there has been a lot of pipe cracked or broken after the construction of the sewers, and the reason for this was that the pipes were laid and left uncovered until the cement had set in the joints which made one continuous line of pipe and allowed no play in the joints, so that when they proceeded to fill the trench after the cement had set there was no chance for any give in the line of the sewer as the backfilling was being put in place.

Clause 17—The successful bidder must sign the contract for the work to be done by him within ten days after the contract is awarded to him, and must begin work at any time fixed by the engineer for him to begin after ten days from the execution of the contract. He shall proceed with the work, prosecuting it with due diligence at such time and in such places with such force as the engineer may direct during the progress of the work and he must complete the work at or before the time fixed for its completion. Should the work under this agreement not be finished within the time specified, the contractor shall forfeit the sum of $25 per day for each and every day that shall elapse after the date fixed for completion.

You can see that when one or more of the above clauses are put in the specifications it is a difficult matter and practically impossible for a contractor to figure or bid intelligently on the work for it becomes a guess instead of figuring and he can only tell what he is going to have to do when the work is completed and the only way he can come to a basis for a bid is to add a percentage for risks which would be sure to cover the unforeseen obstructions and the engineer cannot expect to get close bids with such specifications and not only that, it bothers the contractor when he comes to secure bonds for the work and makes the bond cost more.

There is generally enough risks to run on this kind of work without putting on additional risks that can as well be covered by percentage clauses. It is also asking considerable of a contractor to sign a contract with a large forfeiture clause in case he is not able to complete the work at a certain date when the quotations he receives on material are headed as follows: "All agreements contingent upon strikes, accidents or other causes beyond our control." Would it not be well to insert this same clause in the specifications and eliminate as far as possible all uncertain clauses in the specifications and prepare them so that the contractor would be able to make a close and intelligent bid on the work and have the uncertain quantity covered by a special clause giving cost plus a reasonable percentage for the use of tools and profits?

City Councils want and should have first-class work and material and a contractor should see that he gets a price sufficient to enable him to do his work in the best possible manner and to furnish good material and not slight his work in any particular. He should do work that he can point to with pride and which will act as a recommendation for his ability and honesty. He should not criticize the plans and specifications at the time of the making of bids. If there are objectionable clauses he should refer to them in his proposal and when doing the work should try to get along with the engineer and City Council in the most agreeable manner. He should find out, before he bids, if there is anything in the plans and specifications that he does not understand and when he commences the work he should be ready and willing to act in conjunction with the engineer. They should work in harmony to secure the best results and accomplish good work and give to the city the best possible service for the money.

PROPER CO-OPERATIVE RELATIONS BETWEEN HIGHWAY ENGINEERS AND CONTRACTORS

By H. S. Mattimore, Engineer of Tests, Pennsylvania State Highway Department, Harrisburg, Pa.

There are many serious problems confronting highway officials at the present time. One of the main factors on which the accomplishment of this work depends is the securing of large reputable contractors to undertake construction of these highways. It is a pure business proposition with these companies, and there is no reason why they will not seek it providing the highway officials make it attractive. This does not necessarily mean exorbitant prices. Fair prices with fair treatment, and intelligent, clear specifications, with competent enforcement generally proves to be a greater incentive than high prices and extensive delays, caused by incompetent inspection, indecision, and indefinite specifications, said Mr. Mattimore in addressing the American Association of State Highway Officials.

Just what do we mean by friendly relations between state and contractor? Theoretically it is a relation between the engineer and the contractor where both parties have the same views regarding the performance of a contract, and where the work is accomplished with little or no friction during its progress. We will have to admit that such a relationship is a Utopian one. In the first place we have one party interested mainly for financial gain, while the other being the purchaser, or his representative, is naturally interested in seeing that the article paid for is in his judgment equal to that which was agreed to.

I do not assume that as a class, contractors, although seeking financial gain, are not willing to live up to their agreement. In fact, I really think otherwise. With very few exceptions our modern contractor is a big business man anxious to do good work and maintain friendly relations and thereby establish a good reputation. On the other hand, our engineers are fair minded, or at least try to be, and their decisions are influenced, only from the standpoint of obtaining what in their judgment is a good quality of work.

Causes of Conflicts

Now the causes of conflicts between the engineers and contractors are many and varied, but broadly they can be summed up, as a difference in view point. This is bound to exist, so long as individuals are of different character and mind, and in fact the stronger the character the more the argument necessary to change the view point. Do not confuse this with ignorant stubbornness. We must be broad enough to realize, that there are many problems in highway work that have more than one correct solution.

The highway official has full power to specify the character of work that the contractor must perform, and in justice to the State, he must see that this work is performed, according to these specifications. This is the source of many of the troubles arising during the progress of the work. The contract is taken by the contractor and he agrees to perform the necessary work in accordance with certain specifications. These specifications are written by the engineers and supposedly understood by the contractor. Now, is this latter always the case? Are all specifications clear? As an answer, consult articles in current numbers of engineering and contracting journals, also examine court records of State, versus contractor on highway cases. In the latter you will find judge, jury and many legal authorities are trying to interpret various clauses in specifications. This, in itself, should convince us that the specifications must be clear. Make them concise if possible, but do not sacrifice clearness.

Clear Specifications

There is much to be said regarding specifications. In the first place they must not be a product of one mind. A real clear and concise specification, if written by an individual, should be done so only after ideas are obtained from men directly connected with the details of construction. Good practice must be adhered to and all methods must be described as definitely as possible.

Do not specify better quality or more detail than you expect to obtain. We have all seen specifications with many paragraphs or phrases, which were apparently written to act as a club over the contractor. They were supposedly intended as an insurance against a dishonest contractor. Such an insurance leads to high bids, and large reputable contracting companies will hesitate before bidding under such specifications, and when they do bid, it will be high enough to play safe.

Occasionally another type of specification is encountered which is so open and broad that it is dangerous. I refer to specifications, which instead of definitely specifying qualities and describing methods, will call for work being done satisfactory to the engineers. This type is a survival of the days when the Chief Engineer or competent assistants could give much time to details. I doubt if such specifications proved satisfactory even then. At any rate, in the present days they would be hazardous for both state and contractor. No man can satisfactorily handle all details in supervising the large amount of work being done at present, and much supervision has to be left to subordinates. It is a careless and unnecessary procedure to place the responsibility of deciding broad questions on men of limited experience. Furthermore, a reader of such specifications is impressed with the idea that the state presenting them was in ignorance of just what they did want.

The main factors affecting the relationship between contractor and the state therefore might be enumerated as: First the type of specification under which the work is done, next the interpretation of these specifications, and finally their enforcement.

Interpretation of Specifications

I have briefly discussed two general types of specifications to be avoided, and too much emphasis cannot be placed on these points. In order to play fair, the engineers or other officials responsible on the part of the state, must see that their specifications are clear in the fact that, methods are definitely stated, as far as practical to do so. If we expect to avoid friction during the progress of the work, we must have a proper understanding of what is expected, and this information should be conveyed in the specifications. We cannot expect a better class of materials and workmanship than is available. If we call for this latter, the result will be, that if the contract is ever completed, we will find that we have not met the specification requirements, but will probably be faced with the fact that we paid the price for them. A reputable contractor will take the specifications in good faith and assume they will be enforced. If they are impractical, or not properly enforced, the State is the loser, as a successful contractor prepares for the worst condition and bids accordingly.

Now all specifications must be interpreted in many points, and as it is within their authority this is entirely controlled by the State representatives. The type of a man invested with this authority is a large factor in determining relationship with the contractor, and also has a great influence on future prices. A broad minded man of experience insists upon an excellent quality of work, but he is reasonable enough not to insist on this being obtained the most expensive way.

The Inspector

A certain amount of responsibility and some authority has to be given to the inspector of the contract. The experience of this man and his general type has a great influence on the work and the relationship maintained. This is the State employe that is most intimately associated with the contractor; and his decisions, although in many cases of a minor nature, are bound to have their effect on the subject under

discussion. It is true, with a good specification, his individual opinions are reduced to the minimum, but we must realize that there are still many points on which he has very little to guide him except past experience and good practice.

An inspector first is to inspect and insist on quality and compliance with specification. Any failure on his part in this regard, is an absolute neglect of duty. It can be said in praise of the engineer or inspector from a moral standpoint, that a very small proportion deliberately err on the side of neglect of duty, so far as their understanding of the specifications are concerned. In fact, their main faults are improper interpretation of the specifications, insufficient detail, knowledge of the different phases of the work which makes them uncertain in making decisions; inexperience unfits them to determine between a major or minor cause for complaint, and finally there is a lack of co-operation with the contractor. This latter, with inexperience, is probably one of the main causes of delays on many contracts. By co-operation, I mean that the inspector should always see that the contract is performed in accordance with specifications, but instead of constantly complaining, he should suggest methods for rectifying poor conditions. His aim should be to secure results and co-operate with the contractor in getting them. For example, in working local materials, the inspector is, or should be, informed on what is required, and having facilities for determining this, he can guide the contractor in working deposits so as to insure acceptable material being delivered at the site of the work. Here, I wish to emphasize, there is no intention to interfere with the contractor's methods of working. The inspector should co-operate to the extent that no large amount of material will have to be rejected after hauling to the roadside. You can readily see how such co-operation on the part of the inspector, while at the same time maintaining quality, will reduce costs to the contractor which in the end results in lower bids.

Avoid Indecision

Another factor is that the State also maintain a reputation for fairness, thereby, attracting the better and more reputable contractors. An inspector should avoid indecision. A firm positive attitude, on his part, will command respect and maintain friendly relations to a greater extent, than will the apparent indecision encountered on many contracts. The complaint from contractors on indecision of the engineer or inspector, far outnumbers those on positive directions, even though the latter is somewhat severe.

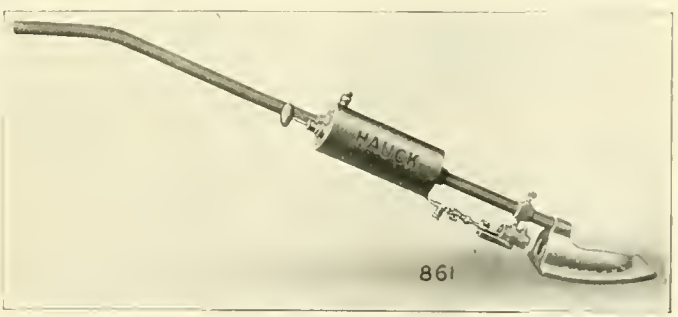
All highway departments should aim to furnish competent, reliable information when calling for bids. This gives some definite knowledge to the contractor, and allows him to bid with intelligence and thereby, reduce his so-called contingency or safety item. Under this head, might be mentioned sources of approved materials for construction. It is expected that a contractor will inspect the highway before bidding, but having no facilities for determining quality, he must figure on sources of known quality, regardless of economy. All available material sources should be investigated by the state and full information furnished with the proposal or bidding sheet. This investigation of materials should be made as complete as possible. So far as I know no attempt has ever been made to guarantee these sources in quality and quantity. It is a question for thought whether it may not pay in the end to do so, but regardless of this I know from past experience that the furnishing of full information on material sources without guarantee has proven economical. These sources although not guaranteed must be reliable, and great care and pains taken in their investigation, or otherwise very little benefit will result.

Highway officials desire to be fair, and hope to impress this sense of their fairness on the contractor, not only to attract bidders, but from the general idea of fairness itself. In order to do this, we must impress the contractor with the fact, that in giving due consideration to the legal side of a contract, we also know and consider the moral side.

A SELF-HEATING ASPHALT SMOOTHING IRON

A kerosene-burning, self-heating, asphalt smoothing iron has been placed on the market by the Hauck Manufacturing Company, 101 Eleventh street, Brooklyn, N. Y., and is here illustrated.

This smoothing iron is claimed to smooth asphalt at one-fifth the cost of the older methods. Four distinctive advantages are claimed for it over the ordinary smoother:



NEW SELF-HEATING ASPHALT SMOOTHING IRON.

1. It does away with the slow, smoky wood fire wagon.
2. It does away with the carrying of the iron back and forth from the heating wagon to the job.
3. It saves from 60 to 75% in fuel costs.
4. It does the work of three men.

It is claimed that the saving in the cost of labor alone pays for the smoothing iron in a very short time. The iron is simple in operation, and it is strongly built for hard usage. Any laborer can handle it successfully.

The heating chamber is in the iron proper. A one and one-half gallon oil tank equipped with a hand pump, filler plug, gauge, a Hauck kerosene burner having oil needle valve and strainer are attached to the handle of the smoothing iron. The burner is so arranged that the flame shoots right into the iron. The burner is protected by a shield.

UNLOADING ASPHALT AND ROAD OIL FROM TANK CARS

The unloading of asphalt and road oil from tank cars is a simple, easily accomplished operation, which requires the knowledge of only a few fundamental principles. These primary but all-important principles may be summarized under the three following headings:

a. Dome cover.
b. Steam inlets.
c. Steam outlets.

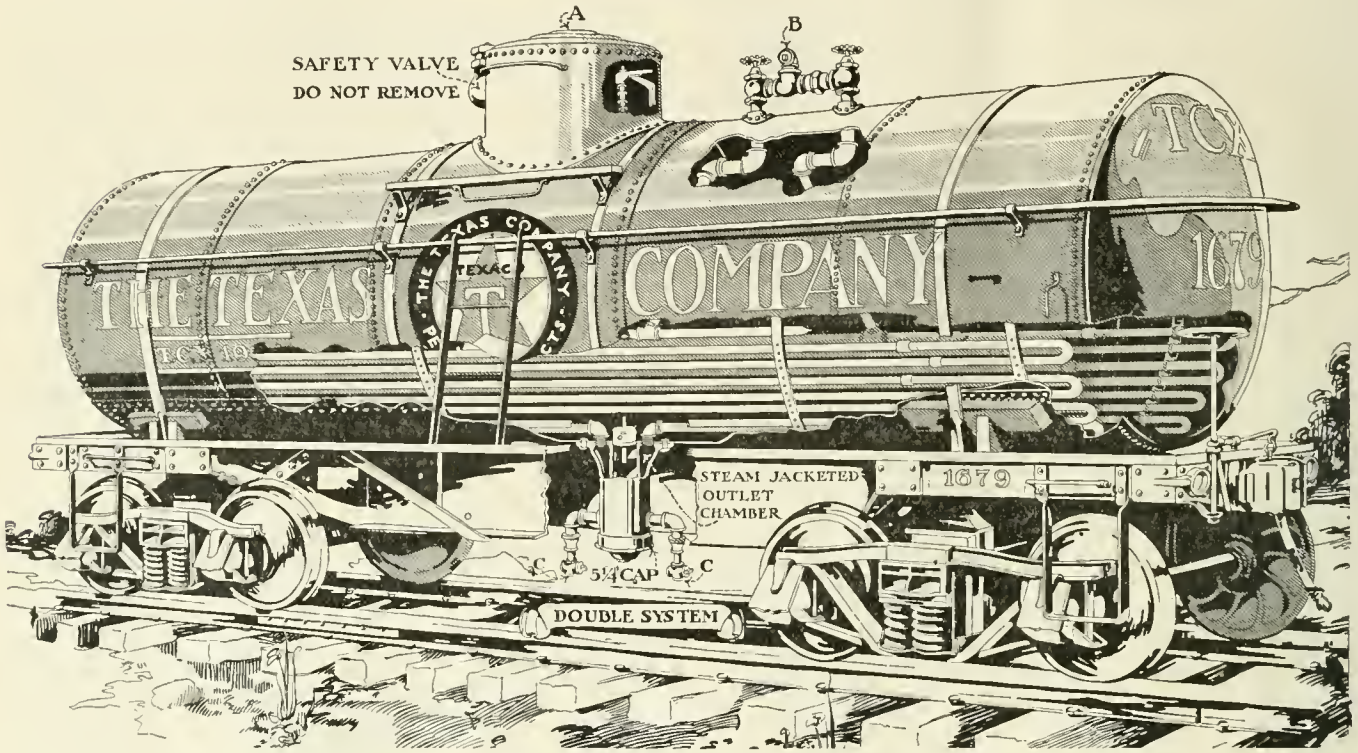


DIAGRAM TO ILLUSTRATE RECOMMENDED PROCEDURE IN UNLOADING ASPHALT AND ROAD OIL FROM TANK CARS.

Through acquaintance with these factors makes the operation of steam coils in tank cars easy, but ignorance of them often results in an infinite amount of trouble and expense.

These three general headings, each supplemented with specific directions, are given above. In reading these refer to the accompanying drawing of a tank car of the Texas Company and follow the lettering carefully.

a. Dome cover—
1. Remove while unloading car.
2. Replace when car is unloaded.
3. Prevent rain or snow from entering dome to avoid foaming of contents.

b. Steam inlets—
1. If car fitted with "duplex" or double system steam coils and one system is leaking, the other can be used by shutting steam inlet valve "B" of leaky system.
2. Steam must be turned into coils gradually to prevent rapid expansion, causing coils to break and leak.

c. Steam outlets—
1. Must be wide open when steam is turned into coil.
2. When live steam begins to show at steam outlets the outlet valves should be turned nearly off, but must never be entirely closed, otherwise the contents cannot be sufficiently heated.
3. Open steam outlet valves "c" wide, after car is unloaded, so coils will drain to prevent water freezing and bursting steam coils or jacketed outlet chamber.

TRADE NOTES

Permanent headquarters for the Asphalt Association, an organization representing the producers and users of asphalt for paving purposes, have been established in the new National Association Building, 25 West Forty-third street, New York City. From its main headquarters and its branch offices at Washington, Chicago and Toronto the Asphalt Association will continue its educational and research work, looking to extension and development of asphaltic types of highway construction along the most effective engineering and economic lines. J. R. Draney, of the United States Asphalt Refining Company, is president of the association; W. W. McFarland, of the Warner-Quinlan Company, is vice-president; Herbert Spencer, of the Standard Oil Company of New Jersey, is treasurer, and J. E. Pennybacker, formerly chief of management of the United States Bureau of Public Roads, secretary. A feature of the association's activities is a brochure series explaining the approved methods of constructing asphalt pavements, including asphalt macadam, asphaltic concrete and sheet asphalt pavements, and presenting information as to asphalt specifications, the use of asphalt fillers for brick and block pavements. Lectures in universities and colleges have been given, or arranged for, in about twenty-five of the leading educational institutions of the United States and Canada.

Tarvia-KP

FOR COLD PATCHING

Before the "Tarvia-KP" and stone mixture is placed in the hole, it is carefully cleaned out and the bottom and sides painted with "Tarvia-KP."

First aid for Spring roads—

IF your roads are scarred from Winter frosts and Spring thaws—pitted with ruts and holes—prompt patching with the remarkable "Tarvia-KP" will save expensive repair work in the Summer and Fall.

Those bad spots should be repaired—*now*—before Summer comes with its heavy road-wrecking traffic.

"Tarvia-KP" is extremely easy to apply in big or little quantities. No heating is required. Patches made with "Tarvia-KP" will stand up under the heaviest traffic. It is the ideal "first aid" for your Spring Roads. "Tarvia K-P" (Kold Patch) is a bituminous road-patching material that can be mixed and stored up in spare moments and used at any time of year to repair any kind of road. It is in a class by itself for making quick, dependable patches.

Send in *your* Spring order for "Tarvia-KP" today.

Our nearest office will gladly send you a booklet showing each step in patching a road with "Tarvia-KP".

The Barrett Company

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Detroit New Orleans Birmingham Kansas City Minneapolis Nashville Syracuse Salt Lake City
Seattle Peoria Atlanta Duluth Milwaukee Bangor Washington Johnstown Lebanon Youngstown
Toledo Columbus Richmond Latrobe Dallas Bethlehem Elizabeth Buffalo Baltimore

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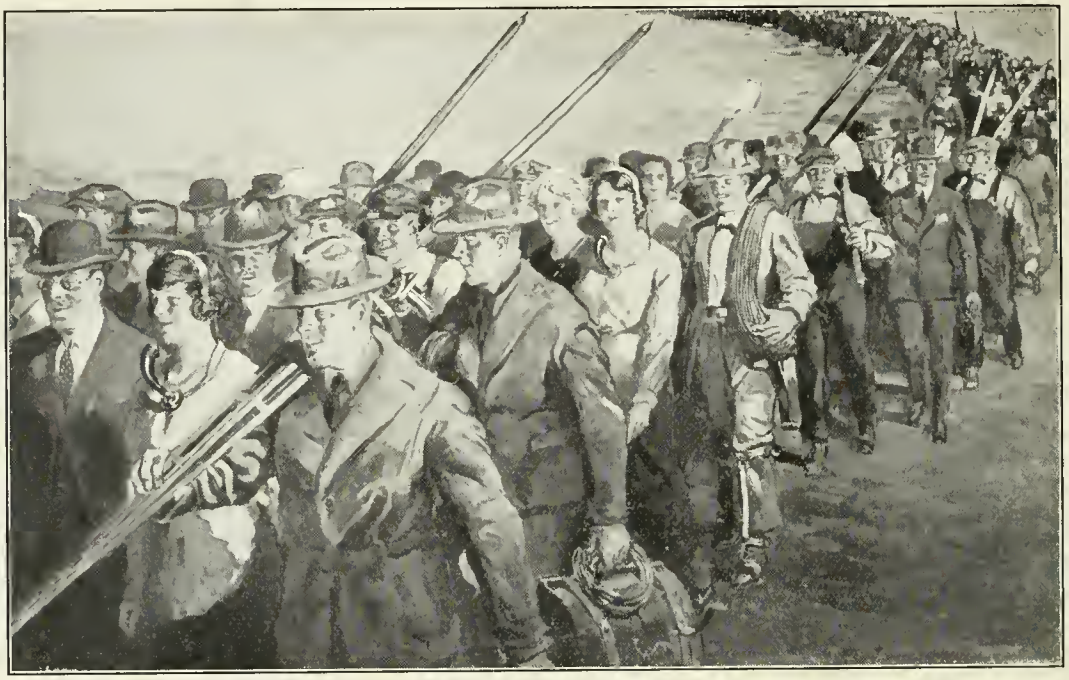

The Human Side of Service

More than a year has passed since the signing of the Armistice, yet all the world still feels the effects of the War. The Telephone Company is no exception.

More than 20,000 Bell telephone employees went to war; some of them never returned. For eighteen months we were shut off from practically all supplies.

War's demands took our employees and our materials, at the same time requiring increased service.

Some districts suffered. In many places the old, high standard of service has been restored.

In every place efforts at restoration are unremitting. The loyalty of employees who have staid at their tasks and the fine spirit of new employees deserves public appreciation.

They have worked at a disadvantage but they have never faltered for they know their importance to both the commercial and social life of the country.

These two hundred thousand workers are just as human as the rest of us. They respond to kindly, considerate treatment and are worthy of adequate remuneration. And the reward should always be in keeping with the service desired.

AMERICAN TELEPHONE AND TELEGRAPH COMPANY
AND ASSOCIATED COMPANIES

One Policy *One System* *Universal Service*

WATER WORKS SECTION

EXAMPLE OF GOOD-WILL ADVERTISING IN WATER WORKS BUSINESS

The citizens of Terre Haute, Ind., are supplied with water for all purposes by a private company, the Terre Haute Water Works Company. Aside from the competition of shallow wells, which is much less formidable than it was ten years ago, this company enjoys a monopoly, and yet it advertises in various ways and regularly. The result of this publicity is that the company enjoys the confidence and good will of the people it serves.

Mr. Dow R. Gwinn, president and general manager of the company, was the pioneer in advertising in the water works field and remains the greatest exponent of advertising in that field. He frequently uses copy in local newspapers to render an account of his stewardship and to keep the public informed as to the purposes and ideals of his company and also with reference to certain matters of operating detail, knowledge of which makes for pleasant relations between the private company and the public.

A recent newspaper advertisement is here quoted as a sample. The advertisement appeared in the Terre Haute Star of Feb. 18, 1920, and measured 10x15 ins. The advertisement was headed "A Report to the Good People of the Good City of Terre Haute." It follows:

"It seems right that we, as the public water purveyors of the city of Terre Haute, should give an account of our stewardship. Therefore, we wish to advise—

"That the U. S. Public Health Service has fixed a high standard of purity for water used by railroad companies whose lines pass from one state to another, and twice each year certificates must be furnished showing that the water is up to the standard. These certificates were furnished in respect to the city filtered water of Terre Haute by the State Board of Health, Jan. 22, 1919; July 24, 1919, and also on Jan. 15, 1920.

"That we furnish a weekly report to the State officials and they make a personal survey of our plant and an examination of our methods of purification from time to time. At one of the recent visits the Sanitary Engineer said that no filter plant in the State was more efficiently operated than the Terre Haute plant.

"That daily bacteriological tests were made of the natural and also of the filtered water in our own laboratory.

"That visual examinations of the water are made every 30 minutes, or 48 times in 24 hours, and a record is made each time.

"That the average filter efficiency, or bacterial reduction, in 1919 was 96.5%.

"That we have two chemists at our pumping station and one of the officials of our company is a chemist.

"That we are endeavoring to keep informed of the latest and best methods of water purification and water works operation, and with that idea in mind officials of the company attended two State and two National conventions of water works men during the past year.

That the record of typhoid deaths in 1919 in Terre Haute was the lowest on record. This record improves as the number of consumers increases.

"That we offered to test samples of milk in our laboratory for the city without cost.

"That extra water pressure was available for the 563 fire alarms during the year.

"That recording pressure gauges registered the water pressure for every minute in the past year. The steam pressure and the speed of the big pump are also recorded.

"That, owing to the greatly increased cost of operation, the Public Service Commission authorized an increase of rates in April which affected the rate for fire hydrants and also large consumers of water—about 150 in all. The increase did not affect about 98% of our customers in any way. The minimum rate for the popular sized meter was not changed, and it is still 75 cents per month; in 1915 it was $1 per month, or $12 per year.

"That the water rate per 1,000 gallons for the first 20,000 gallons per month in 1919 was 25 cents, as compared with 30 cents in 1914.

"That the average cost of slack coal purchased by us in 1919 was $2.71 per ton, as compared with $1 in 1914.

"That the cost of treating the water per 1,000 gallons in connection with purification is about double what it was in 1915.

"That the 4½% bonds of the company came due June 1st and were retired by issuing 6% five-year securities, which were sold at 94. The average cost of the company for the money being 7.63% instead of the old rate of 4½%.

"That after paying expenses, taxes, depreciation, cost of borrowed money, improvements and sinking fund requirement, there was a balance of only $6,187.18 for the year 1919.

"That under orders of the Public Service Commission of Indiana the surplus earnings of the company must be used for retiring indebtedness, or for improvements. Therefore, the holders of the common stock did not receive dividends—in fact, have not had any since April, 1916, and cannot have any for over four years more.

"That it required 13 cents of every dollar received for water service during the year to pay the city, state, county and Federal taxes.

"That wages were increased in October, making five increases in two years; wages and salaries have been increased approximately 61% since 1915.

"That the average monthly metered water bill in 1919 was $1.93. Omitting the railroad and industrial consumers, the monthly average was $1.27.

"That ninety-seven (97%) per cent. of all consumers

Printed as insert to Municipal and County Engineering, Chicago, Ill., March, 1920.

are metered. The 3 per cent. are in small houses without bathrooms and sprinkling privileges.

"That we maintain at our pumping station a beautiful park and tennis court which is open to the good people of Terre Haute.

"That several of the employes have been in the water works business for over a third of a century and one has been with this company 29 years.

"That we now have 100.9 miles of water mains, and in August there were 2,567 vacant lots suitable for residences on the streets where there are mains.

"The business of the company is regulated by the Public Service Commission of Indiana, which under the State law establishes the rates that it may charge, fixes the valuation of the property and the rate of interest that it may earn, audits the books and controls the issue of bonds and stocks.

"The quality of the water furnished is under the control of the State Board of Health. The officials of the U. S. Public Health Service inspect the plant.

"The State Fire Marshal, the National Underwriters and the Indiana Inspection Bureau inspect the plant to determine if the fire pressure service and general equipment are satisfactory from the fire protection and insurance standpoint.

"The management of this company believes that it is charged with a very important public duty and that it is responsible to the public for its stewardship; that it is serving the stockholders best when it is furnishng the public with pure water, good service and courteous treatment; that it is its intention to so conduct the business that the good people of the good city of Terre Haute will continue to have reason to be proud of the Water Works System.

GUIDING PRINCIPLES IN WATER PURIFICATION PLANT OPERATION

By W. H. Dittoe, Chief Engineer, Ohio State Department of Health, Columbus, Ohio

The experience of the Ohio State Department of Health in connection with the control of operation of water purification plants has led to the adoption of certain guiding principles, as follows:

1. Every filtration or disinfection plant should have some degree of technical supervision, and filter plants having capacities of 1,000,000 gals. per day or more should be under daily technical supervision. The superintendent of filtration, whether employed constantly or intermittently, should be given full authority over the plant and other plant employes. As the problem is principally plant operation and maintenance, the employment of an analyst to examine samples and act in a merely advisory capacity does not provide efficient supervision.

2. The superintendent of filtration should be qualified by training in water supply engineering, chemistry and bacteriology, and when employed for the larger plants should have had experience in the operation of a smaller one. In rare instances it is possible for a man to become qualified by experience without fundamental technical training.

3. In passing upon the operating results of a water purification plant the efficiency of each individual process should be considered independent of the next succeeding process. Coagulation must be efficient to prevent excessive load on filters. When daily technical supervision is not provided, a factor of safety must be furnished by using constantly a quantity of coagulant as specified by the department in excess of that which would otherwise be required. The rate of operation of gravity rapid sand filters should not exceed 125,000,000 gals. per acre per 24 hours, and if this rate is exceeded, filter efficiency suffers. Disinfection should be applied to filter effluents and must be a true factor of safety.

4. The final effluent of the purification plant must show negative presumptive tests for B. coli in at least 80% of all samples collected throughout the month. If the construction of the purification plant will permit, this standard is applied to the effluent of the filters before disinfection, in which case disinfection becomes a true factor of safety.

The beneficial effects resulting from technical local supervision of plants and state supervisory control cannot be definitely expressed, but there are certain features which may be cited, as follows:

a. Under such operating conditions the constant production of satisfactory water is assured. This is particularly important in Ohio, where so large a percentage of the population is dependent upon purified water.

b. The total cost of plant operation and maintenance will in many instances be reduced. The greatest saving is in the cost of chemicals and frequently exceeds the salary of the superintendent.

c. The knowledge gained from close study of operation of water purification plants throughout the state has enabled the department to give helpful advice to municipalities and their engineers when engaged in projects involving the construction of new plants, and this knowledge has permitted the department intelligently to pass upon plans for such improvements.

d. The system including local technical supervision with state supervisory control has furnished a medium for the interchange of information whereby the accomplishments or mistakes in the operation of a particular plant are made beneficial to the superintendents of other plants.

Acknowledgment

[These principles were stated by Mr. Dittoe in his paper before the latest annual meeting of the American Public Health Society.]

UNIQUE RESERVOIR DAMS ON NEW YORK BARGE CANAL

Among the many imposing structures which have been provided on the Barge Canal of New York there are none which serve better to show the advance made in engineering science of late years than the dams which have been constructed both on the canal and at such points as it was deemed advisable to locate storage reservoirs. These structures involve a variety of types and each was constructed to meet local conditions and afford a solution to some of the vexing problems which have made the Barge Canal one of the greatest engineering feats of the

present age. Some of these dams have been very carefully described by State Engineer Frank M. Williams, of New York, as follows:

One of the most vexing problems connected with the construction of the Barge Canal was that of providing an accurate water supply to assure the minimum depth of 12 ft. in the Barge Canal channel east of the Rome Summit level under all conditions and the difficulties of securing such a water supply were greater at this point than at any other portion of the Barge Canal. To help solve this problem two storage reservoirs have been constructed which, together with other feeders, now supply the water required.

Gravity Dams

One of these reservoirs is situated approximately five miles north of Rome, impounding the waters of the upper Mohawk River in a natural basin in which the village of Delta was formerly located. The dam at this reservoir contains about 90,000 cu. yds. of masonry, it is 1,100 ft. long and has a 300 ft. spillway near its center, the maximum height of the dam being 100 ft., while the overfall from the crest to the pool below is about 70 ft., the water in the pool being at least 12 ft. deep and acting as a cushion to break the fall. The reservoir has an area at crest level of 4½ square miles and a maximum depth of 70 ft. Its capacity is 2,750,000,000 cu. ft. of water, which is drained from a watershed of 137 square miles.

The other new reservoir is formed by a dam across West Canada Creek near the village of Hinckley. This dam is 3,700 ft. long and is mainly an earthen structure provided with a concrete core wall. At the creek channel there are gate chambers and a spillway 400 ft. long. The masonry contents of this dam are 110,020 cu. yds., while the embankment contains 611,200 cu. yds. of earth. The maximum height of this structure is 82 ft., the overfall at the spillway being 61 ft. The area of the reservoir at crest level is almost five square miles and its maximum depth is 75 ft., while the total capacity of the reservoir is 3,445,000,000 cu. ft. of water, which is drawn from a watershed of 372 square miles. The watersheds of both the Hinckley and the Delta reservoirs lie on the slopes of the Adirondacks, the region of greatest precipitation in New York State.

The Crescent dam, which stands at the foot of Mohawk River navigation, just below the entrance to the land line between the Mohawk and Hudson Rivers, is worthy of much attention. This structure is of the gravity, overfall type and is curved in plan. Its length is 1,922 ft. and it extends in a semi-circle on a radius of 700 ft. The eastern portion of the dam spans the old river channel, while the western section extends over low land that has been submerged. The crest of the dam is 39 ft. above the apron. The structure is slightly over 42 ft. wide at its base and is 11 ft. and 5 ins. wide at the top. It has raised the Mohawk River 27 ft. above its former level and created an artificial lake about 10 miles in length. A power house at one end of the dam provides all the electric current used in operating the five massive Waterford locks and other structures between the Hudson and Mohawk Rivers and there is still available some thousands of horse power which could be generated for manufacturing purposes.

Always an Asset

Never a Liability

IN addition to its permanent value U. S. Cast Iron Pipe possesses many other practical features—may be relaid after years of service in another location—has a definite salvage value of from 40 to 50 per cent of its original cost—high flow capacity, tightness, strength and resistance to electrolytic as well as corrosive action, and is impervious to rust. It is interesting to note that 95 per cent of all water mains laid in 1915, the last time statistics were compiled, were **Cast Iron.**

Write for further details.

UNITED STATES CAST IRON PIPE AND FOUNDRY CO.

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Birmingham, Ala.—1002 Am. Trust Building
San Francisco—Monadnock Building
Cleveland—1150 East 26th Street
Dallas, Texas—Scollard Building

For quotations or estimates apply to nearest sales office.
For literature or special information apply to Publicity Department, Desk 6, Burlington, New Jersey.

Movable Dams

Of the movable dams, which have been provided in sections where a fixed dam would add to the flood danger, the bridge type is the most prominent in both numbers and novelty. Eight of these imposing, bridge-like structures span the Mohawk River between Schenectady and Mindenville. These dams have abutments, piers and superstructures like ordinary steel bridges, but from the downstream side of each hang steel frames, resting in concrete sills that stretch across the stream between the abutments and piers. These frames are 15 ft. apart and upon them run gates 30 ft. wide which are placed in tiers of two or three. Electric winches running on tracks on the bridge floor raise the gates by means of heavy chains, while by raising one or more of the gates the operator of the structure is enabled to govern the depth of water in the pool above the dam. During the winter months both the gates and frames are raised to a horizontal position under the bridge floor of the dam, thus leaving the river channel unobstructed during the early spring flood period. These dams range from 370 to 590 ft. in length, while, in constructing the dam at Scotia, a soil was encountered that necessitated the use of pneumatic caisson construction.

Another form of movable dam of which there are several examples on the Barge Canal is the type known as a Taintor or sector gate dam. Local conditions have governed the manner of using this type in the several sections where it has been adopted. The largest Taintor gates in the world are located at a dam near Waterford, N. Y.

GYPSUM ROOF DECKS FOR HYDRO-ELECTRIC BUILDINGS

By Curtis F. Columbia, C. E., 50 Union Square, New York City

Municipal and County Engineering Magazine reaches busy men in almost every line of construction and designing work. And of late these busy engineers have given much time to the discussion of the various types of roof deck adaptable to hydro-electric power plant construction.

There are special features with reference to the roof framing and roof deck construction which deserve special consideration. The designer is taxed to the limit in order to make his designs conform to the standards of good engineering practice, as well as at all times keeping foremost in his mind those two words which today are receiving so much attention—"low cost."

FIG. 1—THE LIGHT REFLECTING UNDER SURFACE OF GYPSUM TILE ON THE PHILADELPHIA SUBURBAN GAS CO. ROOF.

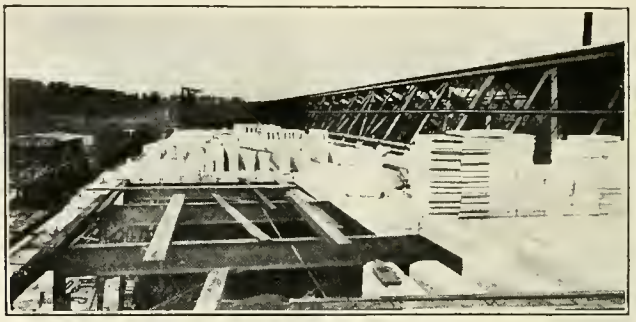


FIG. 2—GYPSUM TILE DESIGNED FOR ALL POSSIBLE LOADS. NOTE THE HEAVY PILE OF TILE TO THE RIGHT OF THE ILLUSTRATION.

Thus two factors must have equal importance, economy and design, because an engineer's reputation is not only based upon the design his drafting will turn out, but also upon the money it is necessary to invest in order to perpetuate those plans, and his future reputation rests with the permanency of his building. These are the monuments on which his ability is judged.

There are certain elementary features regarding the construction of hydraulic power plants which in a general way should be reviewed, in order to determine the proper choice of roof deck material.

The building site plays a most significant part with reference to roof deck construction, in so far as climatic conditions are concerned. Air humidity is the foundation of the cause of condensation, and any likelihood of vapor condensing on the under side of roofs in a hydro-electric plant where steam and moisture is almost universally found, is a problem for most serious consideration. It is obvious that the location of a hydraulic power plant is limited to the place or places where water power is available. The choice of the electric system then depends upon the amount of power, the nature of the load, distance to which power is transmitted and the relative value of power.

FIG. 3—GYPSUM TILE WEIGH 50 PER CENT. LESS THAN CONCRETE.

The First Problem

No matter what power is developed, roof insulation is essential. Turbines for high or moderate heads, impulse wheels for high heads, high or low speed steam engines, simple, compound, condensing or non-condensing, prime movers must be considered alike, for in all cases condensation is bound to occur unless proper thought is put upon the selection of such roof deck material that will eliminate condensation. Gypsum solves the condensation problem to an astonishing degree. Vapor condenses on the under side of a roof deck because of a difference of temperature of the external air and that of the air within the building. A material which will eliminate the transmission of heat then will also eliminate the formation of condensation. Gypsum is a remarkable insurance against the formation of water vapor.

Many heat transmission tests, conducted by such authorities as Professor Norton of the Massachusetts Institute of Technology and many others prove that gypsum transmits less heat units than any other material used for roof deck construction. Gypsum also minimizes heat loss through the roof, which is a decided advantage of all buildings which must be heated during the winter months and of utmost importance during the summer months, as the interior of the building is kept at a constant cool temperature, which condition is becoming almost essential for buildings housing high powered machinery. This heat saving reduces substantially the consumption of fuel, as well as effecting a large saving in initial cost of heating plant and air cooling devices.

The Second Problem

The second problem which is most frequently met with for this particular type of structure is the elimination of the necessity of interior columns at frequent intervals.

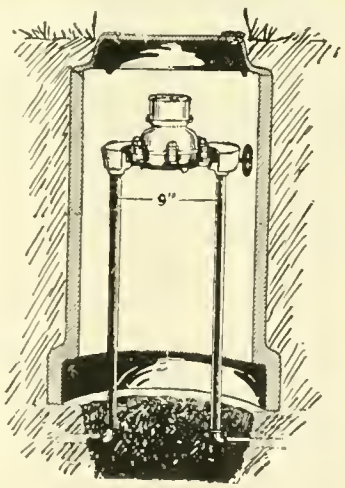
In reviewing a great number of plans and specifications for hydraulic plant construction it will be noted that the roofs of power plants, generally, are supported by means of trusses which are in turn carried either on columns at the side or on masonry walls. The masonry wall support is well illustrated in Fig. 1, which shows the long span truss of the Philadelphia Suburban Gas Co.'s plant at Philadelphia, Pa.

The trusses may be of steel or a combination of wood and steel. For fireproof buildings where the walls are of masonry the steel truss is usually used, but combination trusses are often used in wood buildings requiring large floor space free from columns and in many cases in large brick and stone buildings which are frequently met with in municipal construction work. It is obvious, therefore, that in order to have these ideal conditions it is quite necessary that the roofing be made of such material as to give the lightest possible load. Here again gypsum solves the second problem, because gypsum is just 50% lighter than concrete, far lighter than terra cotta and various cement roofs. At the same time gypsum roof decks are designed to carry the full weight of roof covering, and such dead and snow loads as may come upon it.

The Third Problem

The third big problem is that all construction where

McNutt Meter Setting Specialties



As a result of our rigid policy of maintaining the highest standards of quality and service in **McNutt Meter Setting Specialties,** the demand for our equipment has grown so rapidly that we are now making the second addition to our factory facilities, within eighteen months. McNutt Equipment *makes good*—and we shall leave nothing undone that will improve our product and insure the service that users of McNutt equipment have come to expect.

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high powered machinery is used should be fireproof construction. Gypsum meets most of the exacting requirements and possesses several points of superiority which are peculiar to itself. A sustained temperature of from 1700 to 2100 degrees Fahr. for four or five hours has no effect beyond a slight depth of recalcination on the exposed surface. Subsequent application of water from 1⅛ in. fire hose nozzle, at engine pressure, merely washes away the recalcined surface, leaving the roof deck slab structurally uninjured and capable of carrying, without abnormal deflection, the designed load with ample factor of safety. These conditions of course depend entirely upon the deck design (Fig. 2).

Types of Gypsum Roof Deck

There are two generally accepted types of gypsum roof deck, "poured roof" and "precast tile." Each has its advantages. The poured in place roof is a somewhat unique construction in which steel cables are suspended from truss to truss, and are imbedded in a slab of gypsum which is poured on the job, the cables taking up the full roof load. This is popularly known as "Robertson's process roofs," which has met with wide acceptance and use by engineers of hydro-electric plants and the various departments of the United States government. The precast tile are manufactured in definite sizes and shipped to the building site ready for immediate erection. With the tile no form work is required, the tile being laid directly

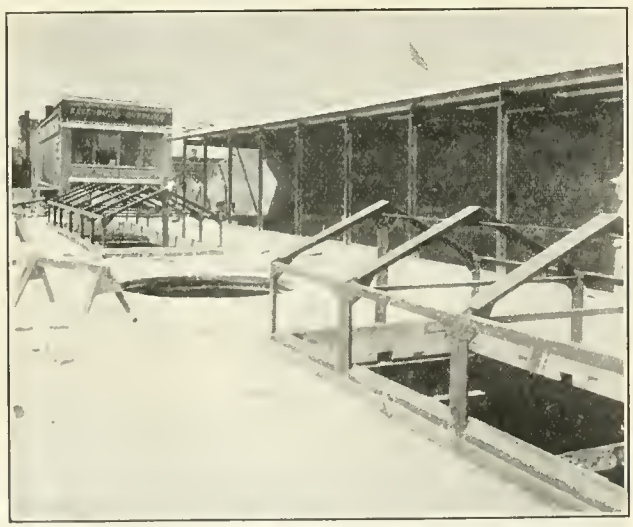


FIG. 4—THE GYPSUM TILE ARE EASILY CUT TO FIT ALL ROOF REQUIREMENTS FOR THE KANSAS CITY POWER AND LIGHT CO.'S PLANT.

on steel or wood trusses (see Fig. 3). The units are placed without mortar, the joints between the tile being grouted with cement gypsum plaster after they are in place. As each tile is individually machine moulded the surface of the roof is practically uniformly smooth and therefore makes an excellent surface for the application of roof covering. But what is of very great importance is that the tile can be easily cut to fit any roof requirements (see Fig. 4). Gypsum affords a dense and excellent nailing surface for roofing, gutters, flashing, cornices, etc. In pitched roofs where heavy slate or ornamental tile is to be nailed direct to the gypsum roof deck, especially dense tile are supplied so as to provide the holding power of nail required. This condition exists largely for hydro-electric plants where the red terra cotta tile is frequently used.

It is impossible within the scope of this article to illustrate many of the constructions using gypsum, but it is evident from the test information and actual building operations that reinforced gypsum as a building unit is a practical proposition, both from an engineering and commercial viewpoint.

RULES FOR THE OPERATION OF SEWAGE TREATMENT PLANTS

By H. R. Abbott, President H. R. Abbott Co., Chamber of Commerce Building, Chicago, Ill.

The attendant should carefully inspect all parts of the plant at least once each day.

He should at once report to officer in charge of the plant any unusual condition or imperfect functioning of any part of the plant.

Screening and Detritus Chamber

The screens or racks should be raked at least once each day or more often if necessary to keep them in good condition and to prevent the backing up of sewage in outfall sewer. Screenings should be removed from platform immediately after completion of raking and disposed of either by burial or by incineration. As soon as screenings are deposited in trenches they should be covered to a depth of at least 3 ins. or should be sprayed during warm weather with a 10% borax solution in order to prevent the breeding of flies.

Where detritus chambers have been provided, great care should be exercised to keep them free of heavy deposits. It is essential that they should be thoroughly cleaned at least once each week. Where such chambers are provided with a blow-off, the detritus should be drawn off daily. This operation will obviate any danger of clogging of blow-off line. The material removed from detritus chambers shall be disposed of by burial as required for screenings.

Sewage Tanks

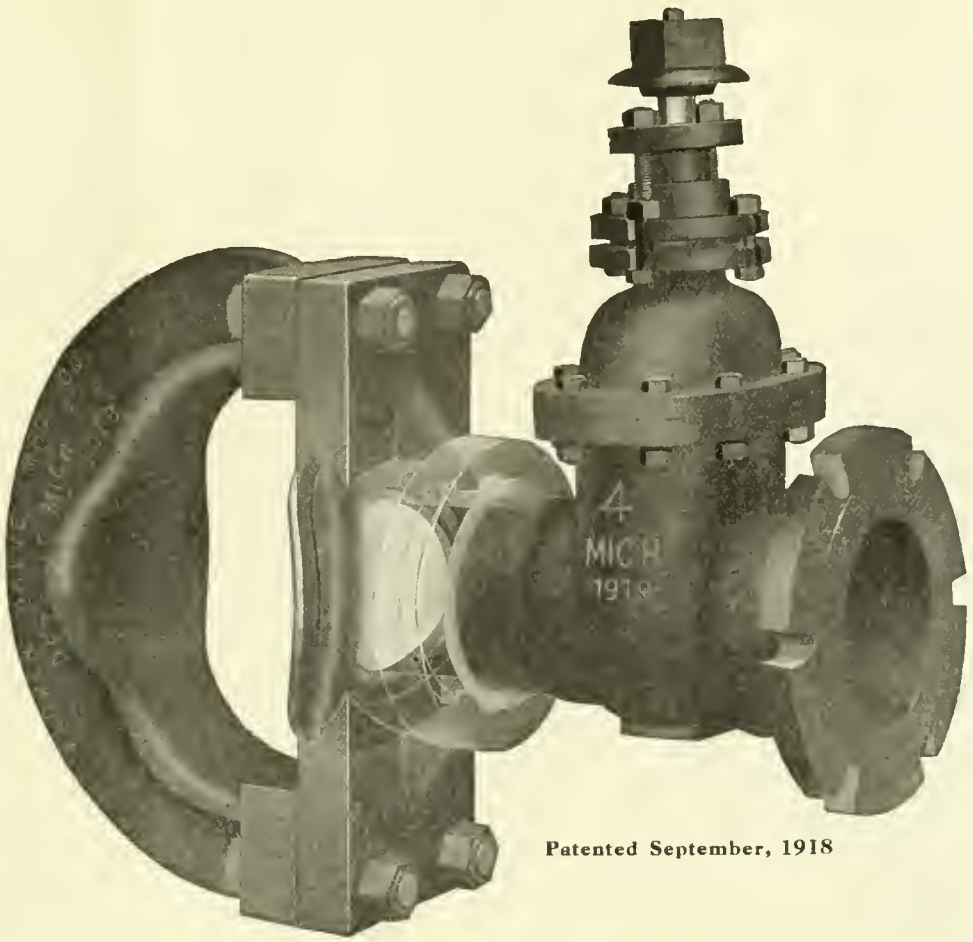
It is desirable to maintain an equal rate of flow through all tanks in service. To accomplish this in certain cases it may be necessary to adjust the valves on inlet pipe lines or gates in distribution chambers. A uniform depth of flow over the effluent weirs of all tanks in service is an indication of proper distribution of flow in the several tanks.

Number of Tanks to Be Used

Where two or more tanks are provided, the operator shall use at one time only such number of tanks as will provide an average detention period of not less than six hours nor more than twelve hours. In computing the detention period the entire capacity of each tank shall be used.

Rotation of Tanks in Service

In case the number of tanks is in excess of requirements, tanks should be operated in rotation, a period of two weeks' use to be followed by as long a rest period as conditions allow.



Patented September, 1918

The Improved Flower Sleeve

Speeds up the work by saving labor—by allowing the use of a shallower trench, by eliminating the slow, difficult job of pouring lead around the joint, and by simplifying caulking and reducing it to a minimum.

If you have not had particulars of this time, labor and money-saver, send for them today.

Flower Valve Manufacturing Co.

117 Parkinson Street Detroit, Michigan

(32)

Operation of Tanks

To produce the best results, care must be taken that all parts of the tank, including all baffles and other concrete surfaces, be kept clean by hosing and use of squeegee.

During the first few months of operation it is essential to break up the scum daily by means of a hose stream or by aid of some mechanical device in order to avoid the formation of a heavy scum, as soon as bacterial action has become vigorous.

When the bacterial development in the tank, especially the first compartment, has reached a certain stage, hosing is required less frequently.

Scum formation varies considerably in different tanks, being dependent on certain characteristics of the sewage.

Lime Treatment for Acid Sewage

Wherever the litmus test shows an acid reaction in the raw sewage, milk of lime should be added in quantity sufficient to neutralize this acidity. The quantity of lime required will vary from 100 lbs. to 500 lbs. per million gallons, depending upon the degree of acidity of the sewage.

Transfer of Sludge

At times it may become necessary to transfer partially digested sludge from the first compartment of a tank to succeeding compartments, in order to facilitate digestion. This is especially important where tanks are being used to their maximum capacity. The transfer may be accomplished by means of a gasoline operated diaphragm pump, or by drawing down the liquid in the last compartments through the draw-down valves and then transferring sludge through the sludge lines.

Where sludge pipe system is provided with a direct connection with a water distributing system it is desirable to agitate the sludge in the bottom of the first two compartments by the introduction of water thru the sludge lines. This should be done in five-minute periods weekly.

Drawing of Sludge

Sludge should be drawn only when thoroughly digested. Sludge in the last compartment should be removed frequently in order to obtain an effluent low in turbidity.

Sludge shall be drawn into sludge beds to a depth of not more than 12 ins., after which sludge lines shall be drained or filled with water or clarified sewage to avoid formation of heavy deposits. Digested sludge should dry to a spadeable condition in three to six days, according to weather conditions. When sufficiently dried the sludge should be removed from the beds and deposited in fills or disposed of as fertilizer.

Siphon Chamber

Very little difficulty should be experienced with the functioning of the siphon chamber. The walls of the chamber should be kept clean by squeegeeing or hosing, and fine screens located in the channel leading to the siphon chamber should be inspected daily.

Sprinkling Filters

Great care should be taken to keep all parts of the filter clean and free from debris. The effluent channel should be cleaned weekly, and the underdrains flushed out when necessary to remove visible deposits.

All nozzles should be inspected daily and cleaned where necessary and broken or bent spindles replaced.

THE ENGINEERING FEATURES OF A GOLF CLUB

By Paul E. Green, of Marr, Green & Co., Civil and Sanitary Engineers, 17 N. La Salle St., Chicago, Ill.

The average person seldom associates a Golf Club with engineering construction, but a moment's thought will convince one that in the building of such a plant, there will of necessity be considerable engineering design and construction involved.

A modern Golf Club with a membership of approximately 250 will have an 18-hole course, a club house, a very complete drainage system, a sanitary sewer system, highways, and a water supply system. As it will usually be located away from the built-up region of a city or town, it will be necessary for it to build its own utilities. Many golf clubs represent expenditures of half a million dollars for land and plant, of which we may say the land represents $200,000, and the club house, etc., $200,000. A very considerable part of the balance will be invested in engineering construction, possibly as much as $100,000.

This $100,000 will be spent roughly about as follows: Grading roads, and landscape work, $50,000; drainage, $20,000; sewerage, $10,000; water supply, $20,000.

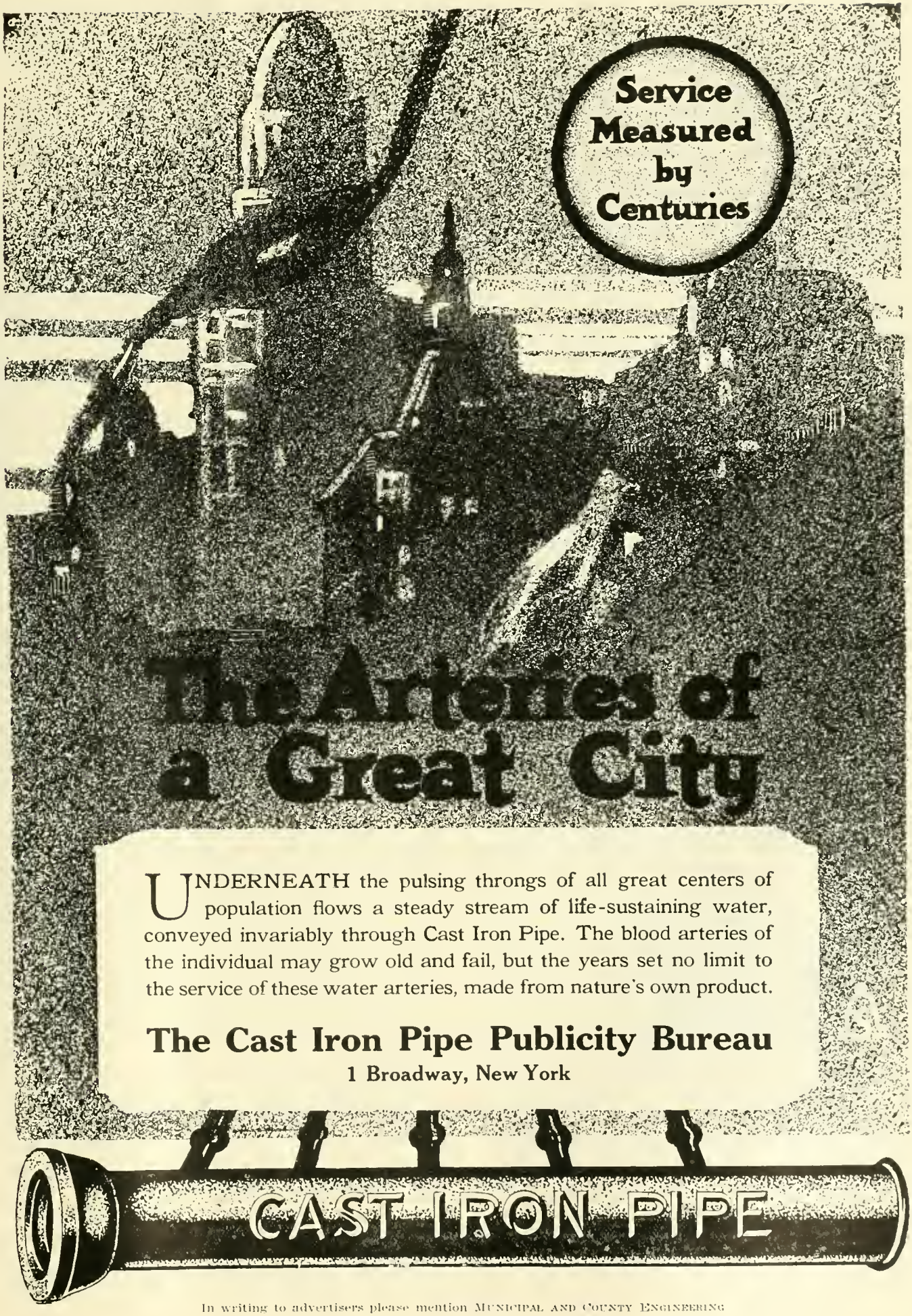
The amount of grading and landscape architecture is surprisingly great, particularly in the prairie states. Bunkers will have to be built involving for each one several hundred yards of earth excavation; sand pits and other hazards provided; the greens built up, very carefully rolled, covered with black dirt and seeded; tees selected, etc. Trees and bushes may be planted, stands of timber partially cleared, and above all the "fairways" and "greens" made very smooth and playable. Small ponds and lakes may be made artificially, and their location must be selected with considerable care, or they will radically affect the drainage. It may be estimated that the construction of an 18-hole course will require the movement of 20,000 cu. yds. of earth, the intensive seeding and cultivation of 10,000 sq. yds. of greens and the seeding less intensively of 250,000 sq. yds. or more of fairways.

Drainage

It is very essential that careful drainage be provided. All the greens, tees, fairways, etc., must be thoroughly under-drained, and most of the low spots on the course as well. Some limited swampy spots may be left as hazards, but it is believed that on an average 6,000-yd. course at least 20,000 lin. ft. of drainage of various sizes from 4 in. up will be required. Besides this there will be a large amount of open ditching, some of which will be desired for hazards.

Sewer System

The club will frequently have as many as 500 people in attendance, and at times twice that many, for whom proper sanitary facilities must be provided. There will be an elaborate kitchen and extensive shower bath facilities. In addition there will be a caddy house and probably other houses for the employes, etc. Furthermore, some clubs now encourage their members to build homes near the clubhouse, possibly a part of the club property being set aside and divided into lots. Thus a sanitary sewer system to take care of 1,000 people will frequently be


Service Measured by Centuries
The Arteries of a Great City
UNDERNEATH the pulsing throngs of all great centers of population flows a steady stream of life-sustaining water, conveyed invariably through Cast Iron Pipe. The blood arteries of the individual may grow old and fail, but the years set no limit to the service of these water arteries, made from nature's own product.
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necessary, and in many cases, a carefully designed sewage disposal plant will be required.

Water Supply

The necessity for an adequate water supply is paramount. A source of supply, pumps, reservoirs, etc., will be required. Without ample water the greens, which have cost thousands of dollars, will be ruined. Each green will require no less than 2,000 gals. per day, or 36,000 gals. for the course. Other sprinkling, etc., must be provided and for the club house, showers, cooking, etc., not less than 50 gals. per member per day. The minimum supply per day provided should not be less than 50,000 gals. and better 150,000 gals.

It is vital to the prosperity of a golf course that the greens be velvety smooth, and the fairways fairly so. In order to keep them in this condition, golf clubs spend a great deal of money in storing and distributing water. It is known that the water for sprinkling must be at air temperature in order to keep the greens in healthy condition. If the water is cold, in a comparatively short time the greens are ruined, which means a loss of thousands of dollars.

Clubs which obtain their supply from wells, whose water is quite cold, find it necesary to establish small lakes or ponds to warm and mellow the water, and from these ponds, the water is pumped to the greens. These ponds may be located at convenient points, preferably rather close to the clubhouse, so that in an emergency, the water may be used for fire protection. They should hold a supply of about 250,000 gals. Not only do they warm the water and furnish fire protection, but they add a hazard to the course as many an inaccurate driver has discovered.

The mains to the greens vary in size from 4 in. to 2 in. and are laid only deep enough to be out of the way, as they are drained in winter. If pond water is used for sprinkling, it is necessary to have a separate system of pipes for drinking water, for sanitary reasons. Half a dozen drinking fountains are required over the course. These may be supplied through ¾-in. galvanized pipe, also laid in a shallow trench.

One other distinctly engineering feature that deserves mention is the roads. Frequently a considerable yardage of roadway must be constructed, not only in the club grounds, but on roads leading to the property. Generally speaking, penetration macadam is the most suitable and cheapest. Traffic is not heavy, though consisting mostly of automobiles, and a few trucks delivering supplies. During the season, it will probably average 200 autos per day, 40 "bus" trips, and possibly half a dozen trucks. This is too much for plain macadam.

During the winter, there is very little traffic, but in the early spring and late fall, the traffic is probably as heavy as at any time, and unless the roads are carefully constructed, with adequate drainage and systematic maintenance, they will get badly cut up.

From the foregoing sketchy review, it will be seen that no inconsiderable problems must be met and solved before a golf club is a going concern, and as there are said to be several thousand clubs in America, the field is not such a small one. Unquestionably many clubs would have saved a great deal of money if they had engaged a competent engineer to assist their golf architect when the course was planned.

CHLORINE PURIFIES POLAND'S POLLUTED STREAMS

American engineers are confronted with many problems in their work of surveying, drainage, sanitation and construction, but it is doubtful if many of them ever went to a town where there was no water to drink except from a polluted river, and even that was controlled by a capricious and heavily armed soldier.

That was the situation in Ratno, Poland, when a relief train of the American Red Cross Commission to Poland arrived in that city, situated on the banks of a branch of the River Pripet. When the train pulled in at the little station a swarm of men, women and children besieged the workers, all asking for one thing. "Please give us a drink of water," they begged.

Major F. W. Yowell, of Washington, D. C., and Lieutenant Paul Van Heck, of Hoboken, N. J., who were in charge of the train of relief supplies, were puzzled at this request. They knew that this town was built on the banks of a river, and yet here were the citizens pleading for a drink of water!

"Why don't you go down to the river and get a drink?" asked the Major.

"The man who runs the river won't let us," was the reply.

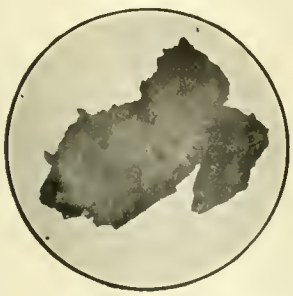
Here indeed was something new. These Red Cross men, in their work of reconstruction, had met many strange situations and queer people, but so far they had not seen a man "who runs a river."

They started out to investigate. When they reached the riven bank they were halted by a big Bolshevist soldier, who at first view seemed all black whiskers and guns. He carried a long rifle, pointed at you in a most unpleasant and business-like manner, and also dangled a sharp sword to give additional emphasis to his commands. Here then was the man who ran the river. He seemed to be making a profitable income out of his enterprise. You see he had no competition and no one to fix his prices, so he could charge as much "as the business would stand." He had been ordered here by the Bolshevist commanders, with instructions to let no one cross the river. This military command he was carrying out with precision, as well as another regulation of his own invention. According to the reports given to the Red Cross relief workers, this soldier was a creature of moods and temperament, and frequently it displeased him to see people of Ratno fill their water jugs from the river, of which he was sole owner, possessor and managing director. So on these days (of which there were many) he would hang out some sort of sign, indicating "No drinks here today."

However, this soldier-boss was not without imagination and not immune to arguments—of a pecuniary nature. The rumor was current that for certain gifts, of goods or coin, he would change his mind and reverse his decision. To those who would part with a slight gift, from palm to palm, he would grant permission to carry away a jug of the beverage they craved. The Red Cross workers pleaded with him in behalf of the thirsty townspeople, but it was of no use. He had discovered a lucrative business, had given himself the exclusive franchise,

Mineral Aggregate and Perfect Mixture Make Kentucky Rock a Super-Asphalt

Here is a grain of silica sand, magnified 250 times. Note its irregular shape and note, also, that it is thoroughly coated with a black substance, which is bitumen.



This photograph, taken through the microscope, explains the wonderful endurance of Kentucky Rock Asphalt.

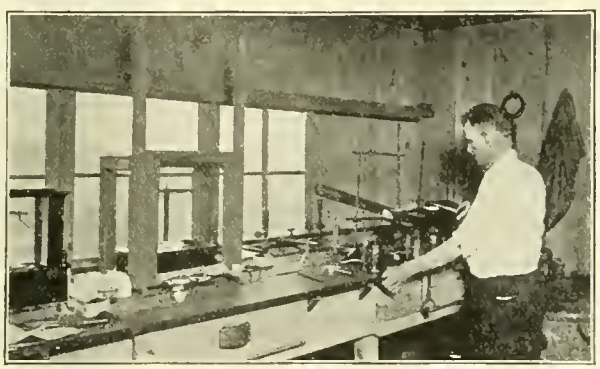
The endurance of a road is measured, first, by the wearing qualities of its mineral aggregate; and, second, by the efficiency of the binder which holds the aggregate together.

Kentucky Rock Asphalt is from 92 to 93 per cent pure silica sand. This sand is so hard that one can readily cut glass with a piece of the natural asphalt rock.

100 Per Cent Coated

Each grain of sand in Kentucky Rock Asphalt is 100 per cent coated with ' umen. Nature has done what would be commercially impossible with hot type or artificially mixed surfacing materials.

The importance of this perfect coating cannot be over-estimated. It insures a bond so perfect that the entire road surface is as compact and solid as natural asphalt rock.



Laboratory where each ton of Rock Asphalt is tested

The individual grains of sand are so firmly bound together that the road surface is absolutely *dustless.* Neither the rigor of weather nor the pounding of traffic can dislodge the particles of sand.

Because of its perfect mixture Kentucky Rock Asphalt is *absolutely impervious to water.* No moisture can creep into or beneath the surface to expand at freezing temperatures and destroy the roadway.

Does Not Crack

Kentucky Rock Asphalt does not crack—neither does it roll, buckle or bleed. It does not lose its life, because it is a natural product laid without artificial mixing or heating. Samples of the material in use for ten years have been analyzed and found as live as when first laid. Where depressions occur in the foundation the Kentucky Rock Asphalt surface often can be broken up and used for patching the hole.

Not an Experiment

Kentucky Rock Asphalt is a proven surfacing material—second to none. Streets of the material laid in Buffalo in 1891 are in use today, and the cost of maintenance has been considerably less than that of other types. Kentucky Rock Asphalt laid in 1909 on the famous Nelson Avenue test road at Columbus, Ohio, was the only one of seventeen materials to pass the test. It is in good condition today, and not a cent has been spent for repairs.

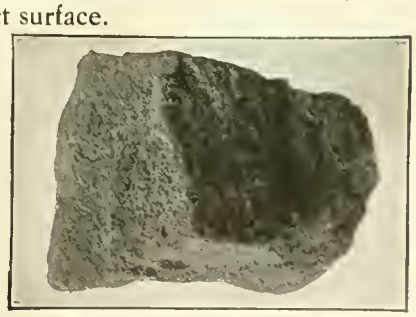
Uniform Mix Assured

Although the presence of the vast deposits of natural asphalt and its wonderful qualities have been known for years, the inaccessibility of the material resulted in its being removed and pulverized in an unsatisfactory manner.

The Kentucky Rock Asphalt Company, which now controls the field, has solved all transportation problems and is removing the material in a systematic manner.

Every ton of Kentucky Rock Asphalt which leaves the mills is analyzed in the Company's laboratory to assure a perfect mixture of sand and bitumen.

Kentucky Rock Asphalt, laid cold on an ordinary macadam base, or used as a resurfacing material on brick, concrete or other solid foundation, will produce a perfect surface.



Natural Asphalt Rock

The saving in mixing and labor make the first cost considerably lower than that of other high class types. The ease and cheapness of maintenance—the remarkable endurance of the material—warrant our assertion that Kentucky Rock Asphalt makes the best road at the least cost. We will welcome an opportunity to prove it.

Write for booklet F. It is a complete and fascinating story of Nature's own paving material.

Kentucky Rock Asphalt Co., Incorporated, 717 Paul Jones Building LOUISVILLE, KY.

and no outsiders were going to stop his declaration of dividends.

The Red Cross relief train went on its errand of mercy without being able to solve the drinking water problem for the people of Ratno. A short time later they heard the report that the Bolshevist conquerors had been ousted from Ratno and that loyal Polish troops had delivered the city. When the Red Cross workers returned to Ratno they learned that the once powerful river boss had been driven out and that the people were drinking freely from the stream.

Another problem arose. Was this water safe for drinking? Chemical examination proved that it was not. Like most of the streams of this region, it was polluted with deadly germs, and its use soon would result in an epidemic of disease. Testing the water supply and then purifying it has been one of the most important relief measures of the American Red Cross. In all their work overseas, both in war zones and in refugee centers, the supply of pure drinking water has been regarded as the first and most urgent need. So it was at Ratno that the Red Cross workers unpacked their army "Lyster bags" and their ampules of calcium hypochlorite and provided something new in the way of a "town pump" for the thirsty citizens. These bags are made of waterproof canvas, with faucets around the bottom, and when they are hung outdoors the slow evaporation keeps the water cool. They were in general use in France with the A. E. F., and many a joke has been written about the "chlorinated highball." The doughboys might laugh about them, but they realized that many lives were saved by drinking from these big water bags, instead of taking the risk of pumps, open wells or streams.

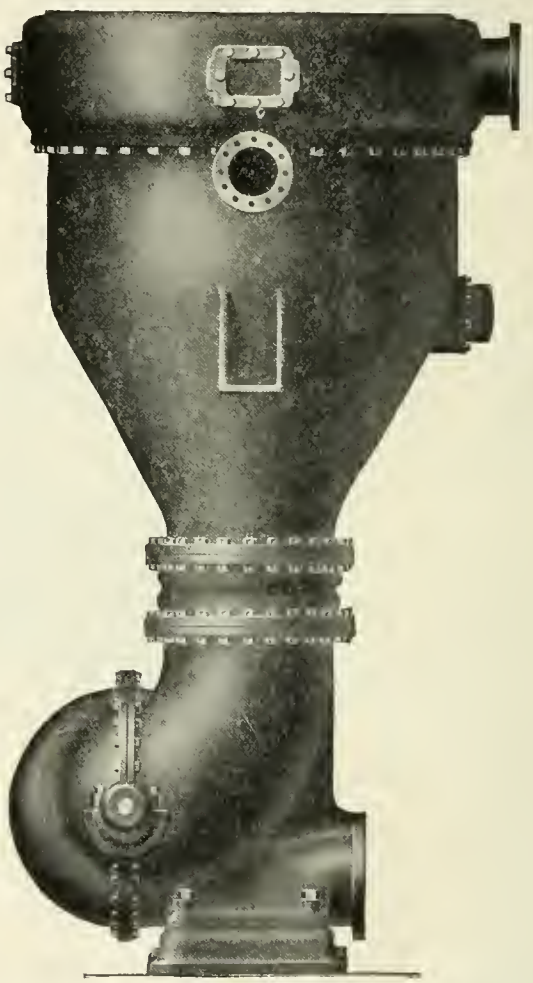
These "Lyster bags" are part of the regular equipment of every relief expedition of the American Red Cross. They have gone with these soldiers of peace and reconstruction into every part of war-devastated Europe, from France to the Balkans, and many lives may be placed to their credit. In Poland especially they have been used extensively. Many deaths had occurred in the Polish Army from preventable diseases that could be traced directly to infected drinking water. Finally the army commanders decided that something must be done, and they adopted the use of these water bags, which had proved so successful in the American Army. Some time ago the Polish Ministry of Health ordered 20,000 of these "Lyster bags" for distribution in army camps and civilian refugee centers. A recent news dispatch from Krakow, Poland, quotes Major Bruce M. Mohler, of Minneapolis, Minn., regarding the purification of Poland's water system. Major Mohler is Deputy Commissioner of the American Red Cross in Poland, and he reports that the use of chlorinated water in soldiers' camps, introduced by the Red Cross Commission, has given the cities of Krakow and Warsaw two of the most sanitary and best protected water systems in Europe.

So the people of Ratno no longer drink infected water, nor do they pay their tribute to a cruel and grafting soldier. The man who ran the river has been replaced by a genial Pole, who warns the people away from the infected stream and directs them to the big Red Cross water bags, where a cool drink may be obtained, in which there lurks no poison germ.

AN IMPORTANT IMPROVEMENT IN WHEELER JET CONDENSERS

The illustration herewith shows the latest design in vertical jet condensers as manufactured by the Wheeler Condenser and Engineering Company, Carteret, N. J. The new feature is the vertically split casing of the tail pump.

This feature permits easy and quick removal or inspection of the pump rotor or other internal part. It is now simply a matter of removing the bolts and cover and uncoupling the rotor. Before this design was developed considerable time was required to get at and remove the rotor.



LATEST TYPE OF WHEELER VERTICAL JET CONDENSER

The improvement is now being added to two types of jet condensers manufactured by this company—the vertical jet condenser and the rectangular type counter-current condenser.

Another feature worthy of note is the expansion joint between the pump and the condenser body. This joint is designed to take care of any changes in length due to temperature fluctuation. In some installations the expansion joint is not recommended, hence condensers are made with or without the joint, depending upon the conditions in the plant.

The primary advantage of the Wheeler jet condenser lies in the fact that it utilizes the heat absorbing capacity of the cooling water to the greatest degree, discharging

it from the bottom of the condenser at practically the same temperature as the steam. At the same time the outgoing non-condensible gases come into contact with the water entering at the top of the shell, and are therefore cooled to the lowest temperature.

Referring to the illustration herewith, steam and water enter at the top. The water is discharged in streams through spiral nozzles, which break up the water current into a rain or spray to insure the desired steam-condensing capacity. The condensed steam and water fall to the bottom of the condenser, where they are removed by the submerged centrifugal pump. The air is removed through an opening just below the cone of the condenser, a small amount of cold water being allowed to fall just in front of the air outlet, thus cooling these gases to their smallest volume.

In connection with these condensers a turbo-air pump or a three-stage steam jet air pump is usually recommended.

ASSOCIATED MANUFACTURERS OF WATER-PURIFYING EQUIPMENT MEET

The annual meeting of the Associated Manufacturers of Water Purifying Equipment was held at the Bellevue-Stratford Hotel in Philadelphia on Feb. 4, 1920. Practically the entire membership was represented at a meeting of unusual progress and interest. Born out of wartime necessity to assist in speedy production of water purifying equipment, the association now continues with the object of assisting in every way the water purification industry as a whole. Much has been accomplished in the past year, in that standard sizes for pressure filters have been agreed upon and much progress has been made by the committees on standards in making preliminary report on sizes and strength of materials entering into filter construction. The committe is also working on the standardization of contracts. It is anticipated that during the coming year an acceptable standard contract form will be prepared for use by the Associated Manufacturers. Mr. Arthur N. Crane, representing the New York Continental Jewell Filtration Company, was elected chairman for the year 1920, succeeding Mr. F. B. Leopold, of the Pittsburgh Filter Company, who was elected to the executive committee to fill the vacancy created by the election of Mr. A. S. Garrett, of the American Water Softener Company, to the position of vice-chairman, succeeding Mr. Crane. Mr. H. M. Tate, of the Borromite Company of America, remains secretary and treasurer. Membership in the association is open to all firms, companies and individuals regularly engaged in the manufacture of water purification equipment whether for filtration, softening or sterilization. It is the earnest desire of the association to have its membership include every organization covered in this classification. It is believed that the association will greatly further the water purification art and the use of pure water.

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Construction News and Equipment

THE DEVELOPMENT AND USE OF MECHANICAL EQUIPMENT IN HIGHWAY CONSTRUCTION

By K. H. Talbot, of Koehring Machine Co., Milwaukee, Wis.

It is not within the province of this article or, in fact, within the province of an equipment manufacturer to discuss costs of doing work or relative costs with given equipment, but only to discuss different types of equipment and their economical use. Each job brings up its own problems and must be laid out according to the type of plant used. In the past, however, there has been a tendency on the part of contractors to wait until they received the job before they decided on the type of plant to purchase. The progressive contractor, however, has changed his point of view and is today purchasing equipment of a type which he feels will give him the best satisfaction and then bids jobs accordingly.

Increased output of finished roads demands three things. First, that the crew be organized; second, that special loading equipment be used; and third, that a larger mixer take the place of the smaller ones in order that the time the material is held in the drum may become a smaller factor in controlling the day's output.

Use of the Belt Conveyor Loader

Economical organization of the crew is dependent, first, on the men themselves, second, on the reduction, by time studies, of the number of men and, third, on the replacement of men by machinery. The first change in machine design looking to more rapid charging of the mixer was the widening of the charging skip to accommodate two wheelbarrows at one time. This proved a great help but still it required wheelers and the output was dependent on the ability to keep the skip loaded. Replacement of men by machinery came with the manufacture of the belt conveyor loader. This consists of a steel frame 60 ft. long, running on traction wheels and operated by a 5-h.p. gasoline engine, as shown in Fig. 1. Standardized measuring boxes furnished with bottom dump doors insure proper quantity of aggregate per batch. On this frame a woven belt 22 ins. long and traveling at the rate of 450 ft. per minute serves to carry the materials forward and place them in the loading skip. Wheelers are no longer required. The number of men in the organization is reduced by six or eight depending on the size of the machine. No more is there a tendency for the crew to become disorganized, for each man has his particular work to do to keep the cycle of operations functioning with clock-like regularity. The minute the charging skip touches the ground the material is dumped through the hoppers onto the belt and 20 seconds later the charging skip is again ready to be raised. In other words, the machine has become a pace-maker for the crew. The illustration gives some ideas of the methods employed in the use of this machine and its successful reduction of man power. It is much easier for a man to load a power-driven belt than to wheel materials through the heat of summer or over a muddy sub-grade.

The contractor is interested, not only in the cost of labor, but in the efficiency of labor and he appreciates to accomplish this and hold his men he must make the work interesting and as easy as possible. It is natural that when men return from the army where they have used mechanical equipment, they are interested in work upon which machinery is used. They will work more conscientiously when feeding a machine than if they were handling wheelbarrows.

Use of Industrial Railway

For some years there has been a tendency toward the use of the industrial railroad for hauling materials in the construction of highways. Among the earlier methods was the use of standard 2 ft. gauge cars dumping into a sideloading mixer. This, however, did not fit the requirements, as, in the first place, the track was not always at the same relative elevation as the mixer, and, in the second place, it was not possible, with the size of the machine, to get full capacity out of the industrial equipment. The batch box system was, therefore, developed and has the advantage of allowing the industrial railroad to be operated to full capacity. The mixer was equipped with a derrick, see Fig. 2, in order that the box might be swung over the loading skip and there discharged.

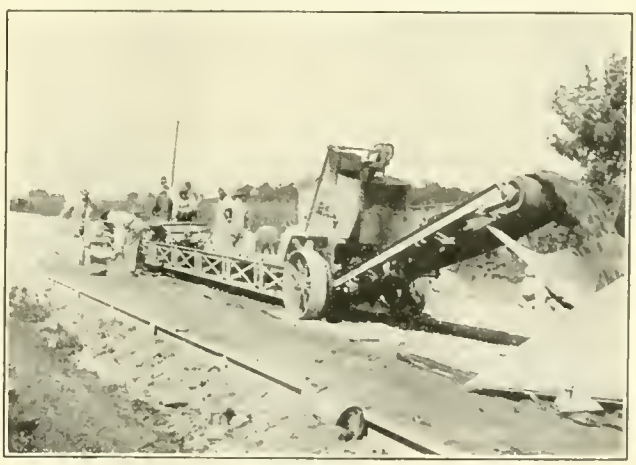

FIG 1—KOEHRING CONVEYOR MIXER LOADER AS OPERATED BY CONTRACTOR R. P. BECKSTROM ON GRANT HIGHWAY CONSTRUCTION NEAR ROCKFORD, ILL.

In the discussion of cars and track, consideration should be given, first, to the design; second, to the number of boxes to a car; third, to the use of the "V"-shaped cars instead of boxes; fourth, to the use of bottom dump in-

Printed as insert to Municipal and County Engineering, Chicago, Ill., March, 1920.

Improved Way to Dig and Convey Materials

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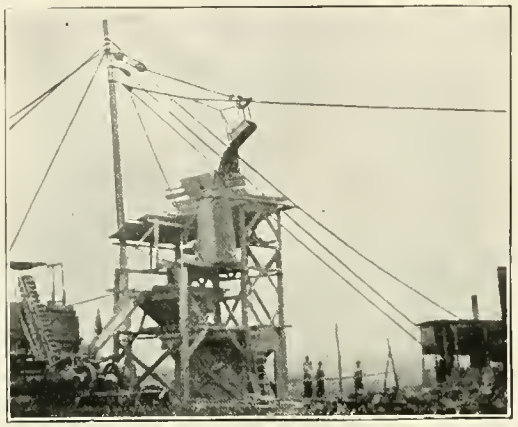

Small Sauerman Cableway operated by 70 h. p. Double-Drum Steam Hoist. This outfit furnishes all the gravel needed for a Michigan Township's road work.

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stead of tip-over boxes, and, fifth, the necessity for quick acting equipment in order that full capacity may be obtained from the mixer.

Industrial Cars

Road contractors have generally standardized on 2 ft. gauge industrial railroad and have accepted the standard 2 ft. gauge cars manufactured by the industrial car manufacturers using frames without platforms and placing the boxes directly on the frame. For mixers holding 14 and 21 ft. of mixed material the use of two boxes to the car has proven the most satisfactory, as this gives full capacity from the standard 1½ yd. industrial car. For the larger mixer, 28 ft. capacity, only one batch should be used per car, as the strength of equipment and weight of rail will carry one batch box satisfactorily, but not two.

The use of "V"-shaped cars loaded to capacity with one aggregate dumped directly onto the sub-grade, the materials then being rehandled to the mixer by use of the mixer loader, has many advantages. The system obviates the possibility of tie-up because of breakdown of a portion of the plant at the loading station, or of transportation equipment, and allows good storage of material, insuring the concreting crew regular work. With the materials for the concrete placed on the sub-grade the system is more elastic than is the one using the batch box. It is also probable that with a given machine more yardage will be placed by dumping aggregates on the sub-grade

FIG. 2—MIXER EQUIPPED WITH DERRICK FOR SWINGING BATCH BOXES OVER LOADING SKIP.

and rehandling than if the quantity placed is dependent on the ability of the contractor to keep a steady supply of material moving to the mixer with the batch box system. However, there is the additional cost of rehandling this material, which doubtless offsets any reduction in cost per yard, due to increased profits. The batch box system has the added advantage that the total number of men in the crew is reduced.

Three Types of Batch Boxes

Some mention should be made of the three types of batch boxes that have been used during the season of 1919. They may be divided according to their method of discharge into: first, tip-over boxes; second, side-dump boxes; third, bottom dump boxes. The tip-over

(Continued on Page 38)

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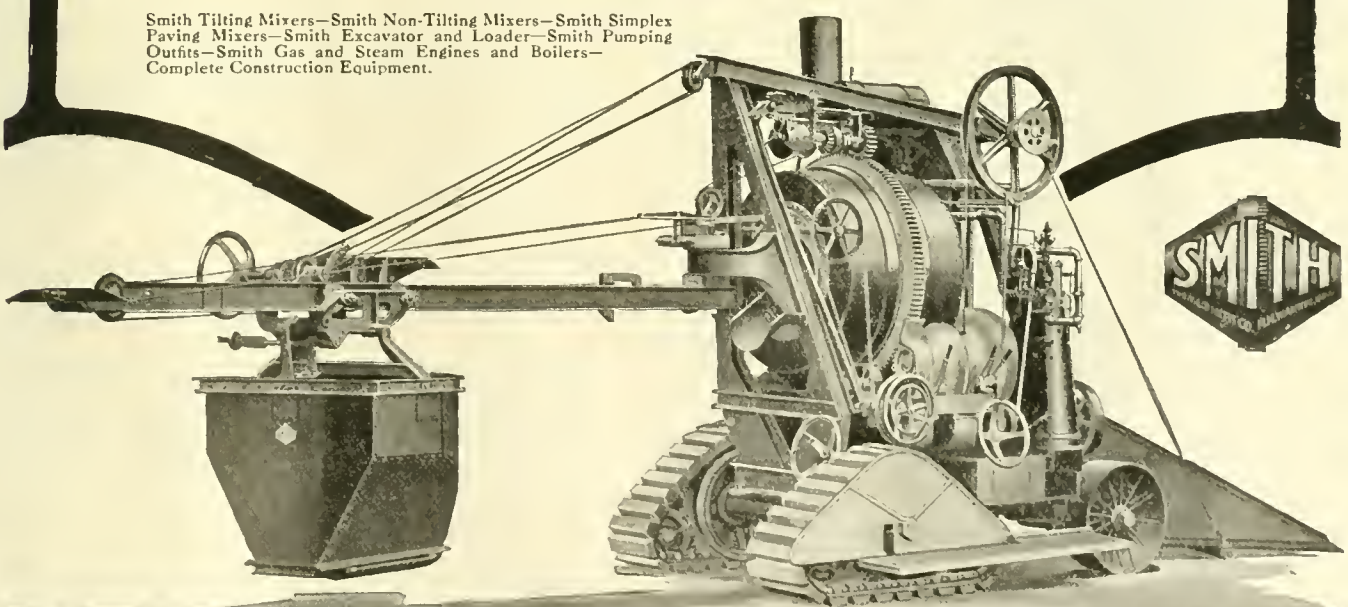

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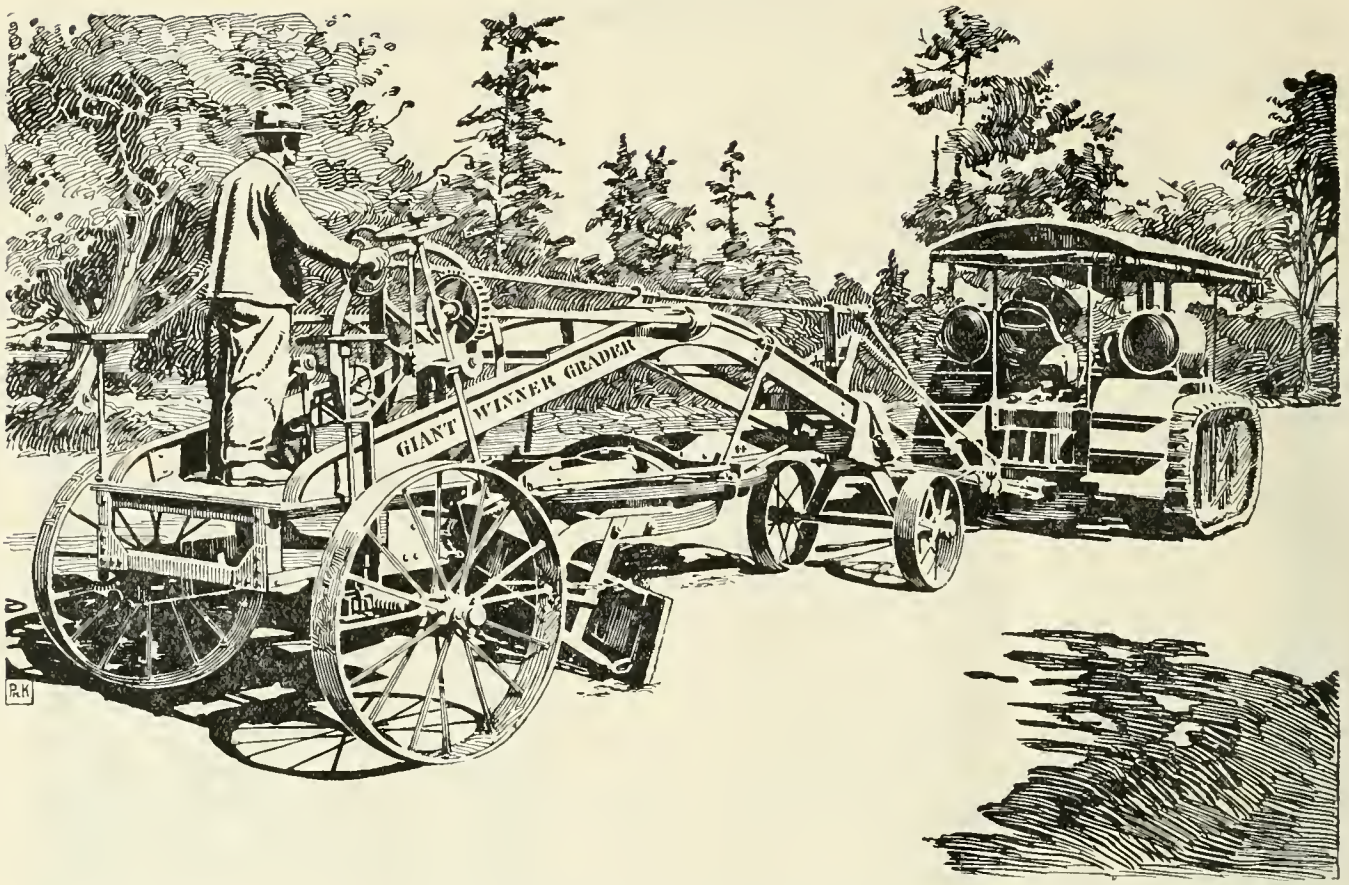

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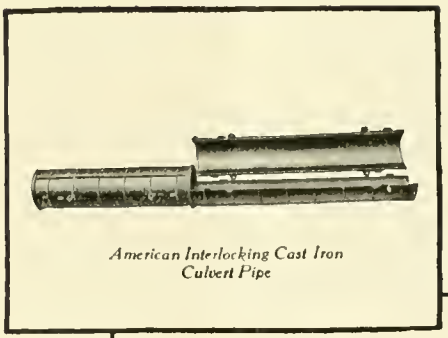

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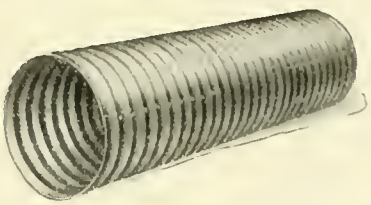
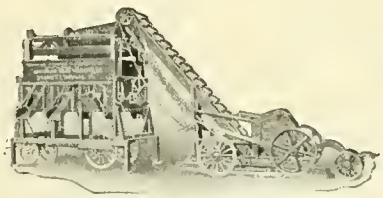


American Full Circle Corrugated Culvert Pipe



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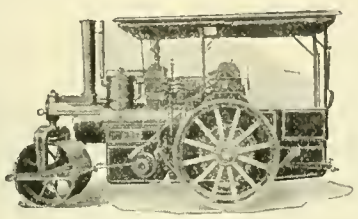

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(Continued from Page 34)

box design utilizes a "V"-shaped car body or has a rectangular batch box with trunnion below the center of gravity of the load, to which the yoke attaches. In order that the cement may be measured in bulk the "V"-shaped body has been divided into three parts by placing a sheet metal box of the proper shape and volume in such a position in the body that the compartments are found in which the volume of fine and coarse aggregate is measured at the same time. In other words, the body or box is divided into three distinct compartments, one holding cement and sand and the other stone. Two objections have been offered to this type of box: first, that the cement compartment does not clear readily, and, second, that the tipping of the box results in a back kick, making it difficult to hold the box in place.

The side discharge box has the advantage of throwing the material well to the front of the loading skip, but has the disadvantage of slow discharge and tendency to kick back. There is no opportunity to separate the cement from the aggregate, and unless the bottom slope of the box is considerable the materials will not flow readily. The sloping of the bottom requires a larger box and also places the center of load higher above the rail and to one side.

The consensus is that the bottom dump box equipped with a separate cement compartment most satisfactorily fills the requirements both for the 14 and 21 ft. paver, where the boxes are dumped by hand, and for the 28 ft. paver where they are dumped by power. With this type of box there is no back kick when the materials are discharged.

Some question has been raised as to the relative advantage of wood and steel boxes. The steel boxes are probably somewhat lighter and are easier to handle when they are new, but once they have become bent they are hard to straighten. The wood box, on the other hand, can be easily repaired, and in case of a wreck a few new boards and a carpenter will have them in working condition within a short time.

Advantages of Fall Line on Mixer Derrick

The 1919 season's work established the great advantage of picking the boxes from the car with a derrick on the mixer, taking advantage of the vertical lift offered by picking them with a fall line instead of obtaining the necessary rise by lifting the boom. The advantages of this method are: First, it is not necessary that the cars be spotted so carefully, as they can be brought to place by tightening the cable. Second, the relative elevation of boxes and mixer is not a factor in the operation, as there is sufficient line to lower boxes 3 ft. below the elevation of the machine if desirable. Third, the derrick is quick acting, there being no delays to the operation of the charging skip while waiting for the yoke to be hooked in place.

Use of Trucks, Tractors and Trailers

Consideration should be given to the use of motor trucks instead of industrial railroad, and also the use of tractors and trailers. No general conclusion can be reached on the relative advantage of these methods of handling materials without knowing the local conditions that exist on a particular job. Motor trucks are entirely out of their class in heavy mud. On the other hand, the industrial track must be ballasted in order that trains may run with necessary speed. If motor trucks are used it is necessary that delays in loading and unloading be reduced to a minimum, as with a rental of $35 a day even short delays are expensive.

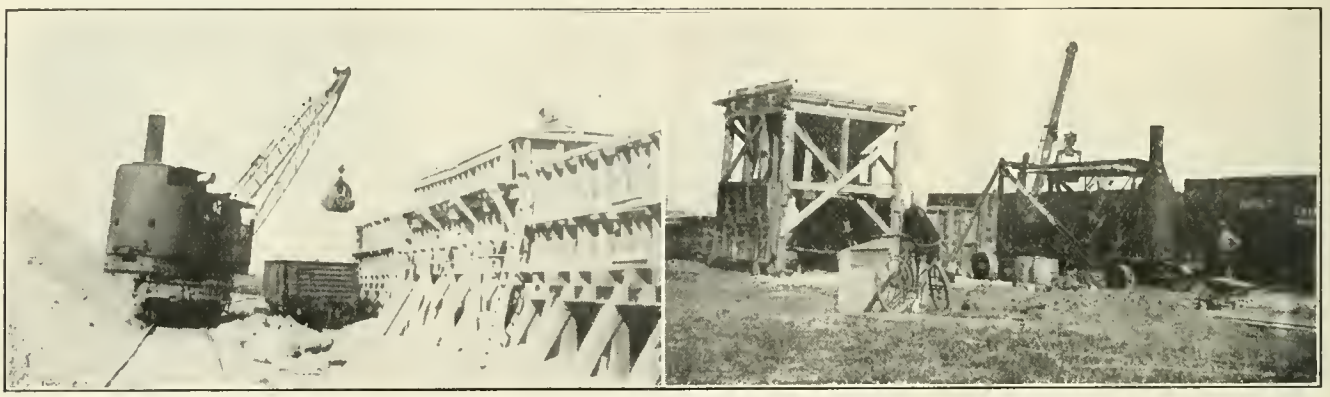

FIG. 3—LOCOMOTIVE CRANE AND STORAGE BINS FOR CEMENT, SAND AND STONE AS OPERATED BY JAMES O. HEYWORTH ON LINCOLN HIGHWAY IN DEKALB COUNTY, ILL.

FIG. 4—BYERS AUTO CRANE AS OPERATED ON HIGHWAY CONSTRUCTION WORK BY H. K. RHOADS AT CLINTON, ILL.

Some contractors have equipped motor trucks with batch boxes while others have divided the body of the truck into compartments and are dumping direct into the loading skip. Under any but the best conditions, however, the economy of this method is questionable, as it is impossible to balance with nicety the hauling schedule of trucks over the newly made sub-grade. The same condition applies to a less degree with the tractor train, but with the last mentioned equipment the objection is not so much the inability to operate on schedule as it is the inability to get into such a position where the derrick on the mixer can easily pick the batch boxes from the wagons. Economy and capacity point to the advantage of dumping materials where hauled by either motor trucks or tractor train directly upon the sub-grade and rehandling to the mixer with a loader.

Unloading Materials at Railroad Station

The unloading of materials at the railroad station offers a problem in design of plant. The method of handling the remainder of the job will, in a large degree, determine the type of unloading equipment. The methods employed for unloading materials may be divided as fol-

lows: First, unloading by hand either into wagons, trucks or into movable hoppers which are hung against the side of the car and from which the material is dumped into trucks or wagons; second, mechanical unloading, using bucket elevators or skip hoists from pits below the track; third, use of clam shell bucket operated by a stationary derrick; and fourth, the use of a portable crane. The first and second of these methods have been very successfully used where comparatively small amounts of materials were handled or where the material could be obtained in bottom dump gondola cars, but will not give the required capacity where the storage must be at the railroad station and not on the sub-grade. The fact that labor is expensive and difficult to get makes it desirable to use labor saving devices wherever possible. It is recommended that consideration be given to the derrick and the crane.

The guyed derrick has many advantages over the stiff-legged derrick for this class of work, as it is possible to swing through 360 degrees and store materials behind it. Stiff leg derricks are being used successfully, but the shorter swing is a disadvantage. If stiff leg derricks are used, however, they should be set up with one of the legs parallel with the railroad track, so that maximum advantage can be taken of this swinging radius.

There are two types of cranes which have been used extensively, first, see Fig. 3, the locomotive crane operating on railroad trucks and handling materials to stock piles parallel with the track, and from them or from the cars into measuring bins, and second, see Fig. 4, the auto cranes which operate either on traction wheels or caterpillars. Either of these machines is satisfactory, the location, quantity to be handled and general conditions determining which to use. Speed of movement and ability to store a considerable quantity of material are essential features.

There have been many advocates of the use of tunnels in connection with locomotive cranes. The expense of such tunnels, however, does not seem to be justified, as against the use of open bins holding between one and two industrial trainloads of material, as the latter are portable to the extent that they can be picked up with the unloading crane or derrick, loaded onto cars and shipped to the next job. They have the advantage of being easy of access, allowing the men to work in the sunshine instead of darkness, and of being easily cleaned in case of any clogging. The placing of the loading bins on flat cars offers many advantages where a locomotive crane is used, as it makes possible the moving of this bin to any place desirable for loading, dependent only on the location of the car to be unloaded.

Design of Unloading Plants

A word of warning on the design of unloading plants may not be out of place here. In the past many contractors have made the mistake of designing their unloading plants with too small storage capacity to allow the crane to store materials as rapidly as it can be obtained. For a one mixer operation it is recommended that a contractor have on hand a storage of at least 2,000 tons of stone and 1,000 tons of sand, and that he equip with an unloading plant having a capacity of at least 300 cu. yds of material per day.

The expenditure of large sums of money for plant requires that all parts be nicely balanced. Many men have found large equipment expensive and have finished the job with a loss because their plants were not balanced. For instance, they may have had a large unloading plant and a small mixer, a large mixer and a large unloading plant, but poor transportation facilities for handling the materials to the mixer, or they have purchased the industrial railway, not affording themselves sufficient storage at the unloading plant to keep going when deliveries were slow.

With a central proportioning plant the use of bulk cement has proven very efficient. The materials in this instance are usually shipped in gondola cars with tarpaulin covers, unloaded with the same clam-shell that unloads the aggregate, and placed in overhead bins from which it is measured by volume into the batch boxes.

Large Mixers

The demand for mechanical equipment is the outcome of the desire of the contractor to reduce the number of men required to build a mile of road per mixing unit. This has brought to the fore larger mixers in order that the unloading and hauling equipment may be used to its full capacity. A mixer holding 28 cu. ft. of concrete equipped with a boom and bucket and charged with a crane having a capacity of from 100 to 125 ft. of 16 ft. road per hour, has been built. Roads have been built at this rate in Michigan.

One batch box is used for each industrial car instead of two used with the smaller machine. The design of the large mixer has been materially changed from that used for a paver with a capacity of 14 to 21 ft. in that the boxes are picked off cars with a separate crane and dumped into a batch hopper above the mixer. In this way one operation is done away with, that of lifting the charging skip.

On machines of 10, 14 and 21-ft. capacity the derrick operated by a power hoist swings the boxes from the car into the loading skip, after which the empty box is swung back and the materials hoisted into place. In this way it is possible to use a standard mixer which may be used either with wheelbarrows or with loader as well as with industrial railroad. The use of a separate crane with the smaller mixers is not economical as the output is not commensurate with the cost.

Based on laboratory results many state highway departments specified the use of concrete having a dry consistency but the results of the work in 1919 point out the desirability of accepting a workable consistency rather than an excess or deficiency of water. In the field there is a point reached where the advantage in strength of concrete, due to reduced water, is offset by the added expense involved in handling the concrete. The boom and bucket distributing system has proven the most economical method of placing concrete on the grade, and it also has the ability to place the concrete on the sub-grade with one man control.

Two Automatic Features in Mixer Design

To guarantee standardized concrete two automatic features have been incorporated into the mixer; first, an automatic water measuring tank, so built that the quantity of water can be controlled and the same amount used for

each batch, and second, the batch meter, which controls the time of mixing.

The measuring of the water is accomplished by filling the water tank to its full capacity and then drawing it down to the bottom of the discharge pipe, the elevation of which can be changed to give the required amount of water. The tank is located crosswise of the machine, so that the quantity of water per batch is the same, regardless of whether the machine is traveling on a level road or on a grade. In order to insure uniform quantity of water per batch the operator should open the valve into the mixer as soon as the last of the preceding batch is discharged and leave it in this position until he has lowered the charging skip. This will give the proper time for discharge of water and insures uniform consistency of the batch.

If, on the other hand, the operator does not open and close the valve at regular intervals one batch will be dry because the tank has not emptied and the next will have the desired amount of water. The result will be a varying consistency.

The batch meter regulates the time that the batch remains in the drum of the mixer, locking the discharge chute when the material enters the drum and releasing it at the expiration of the time specified. Announcement of the fact is made by the ringing of the bell.

Reference has been made to the desirability of the use of machinery as a pacemaker for the crew. One contractor found in 1919 that he was making time and getting out yardage by organizing his crew around the batch meter. The basis of all efficient engineering is time study and timing of operations. The batch meter offers the contractor a time control for his forces.

Plant and Methods Used on Seven Jobs

In order that the meaning of careful planning may be more forcefully brought out, I desire to describe seven road construction operations in as many parts of the country, on each of which a different type of plant was used. Each of these contractors has developed the use of his equipment to the maximum. The operations to be described are as follows:

(1) Tulsa County, Oklahoma, C. O. & H. Frye, contractor.

(2) State Highway, Anoka County, Minnesota, the Widell Co., Mankato, Minn., contractor.

(3) Rockford, Cherry Valley section of Grant Highway, Winnebego County, Illinois, Ross P. Beckstrom, Rockford, Ill., contractor.

(4) Dixie Highway, Kankakee County, Illinois, Bates & Rogers Construction Co., Chicago, contractor.

(5) Lincoln Highway, DeKalb County, Illinois, James O. Heyworth, Chicago, contractor.

(6) Lincoln Highway, Rochelle, Ill., A. E. Rutledge, Rockford, contractor.

(7) State Highway, Branch County, Michigan, G. L. Scharl, Milwaukee, Wis., contractor.

Tulsa County, Oklahoma

The first three jobs noted were similar in that a paving mixer and a belt conveyor loader were used, but differed in the manner of handling materials to the mixer. On the road in Tulsa County, Oklahoma, the contractor had an average haul of less than one mile, and because of the availability of teams handled all the material from the railroad to the mixer with teams and dump wagons. The aggregates were placed in accordance with a predetermined plan, so that he knew definitely the amount required per station. In this way there was no loss due to improper distribution of aggregate and there was no difficulty in getting the aggregate to the conveyor loader. Materials were unloaded from cars into wagons. At no time was the supply of material on the sub-grade allowed to get less than three to four hundred feet ahead of the mixer, and with uniform receipt of materials it was possible to have at least one-half mile of aggregate on the sub-grade at all times. Cement was received in bags handled directly from cars to storage piles along the right of way or else into store houses at the roadside.

So successful was this method that the same type of equipment was used exclusively by other contractors doing work in Tulsa County; in fact, at one time there were in use in Tulsa County five paving mixers with a capacity of 14 cu. ft. of concrete and five conveyor loaders in addition to the mixer and loader described on the Frye work. This is the most simple type of plant, and with sufficient labor at comparatively low price proved very efficient. The storage of materials on the sub-grade guaranteed to the contractor his ability to keep his mixer working even though rain delayed his hauling.

A State Highway in Minnesota

The second operation, that of the Widell Co., Mankato, Minn., is of peculiar interest because of the use of a mixer and conveyor loader with an industrial railroad. In this instance the materials for the concrete were unloaded by a clam-shell carried on a stiff leg derrick. They were placed either in storage piles or else directly into hopper bottom bins, from which the materials were dumped into 2 ft. gauge industrial cars and hauled by locomotive to the side of the work. Here the track was laid directly on the already prepared sub-grade. The stone was dumped on the one side in the required proportion and the sand on the other. Cement was handled in sacks, hauled to the job on flat cars and piled alongside the forms. In order to facilitate handling the cement the track was left in place until the cement was distributed and then taken up. In this way two things were accomplished: First, there was sufficient storage on the sub-grade to keep the mixer going regardless of breakdowns at the unloading plant or in transportation system, and, second, the sub-grade was not cut up. Another point which may be given consideration is the fact that this method of side dumping allows a very excellent path for the loader.

Use of Motor Trucks and Tractor Train

The work done by Ross P. Beckstrom Co. in Illinois offered a study in the use of motor trucks and tractor train for handling material from the railroad station to the mixer. Here again materials were delivered directly on the sub-grade. At the railroad station the aggregates were unloaded by a clam-shell bucket, carried on a stiff-legged derrick handling the material directly into hopper bottom bins or into storage piles on the ground. The motor trucks and tractor train passed under the hopper, received

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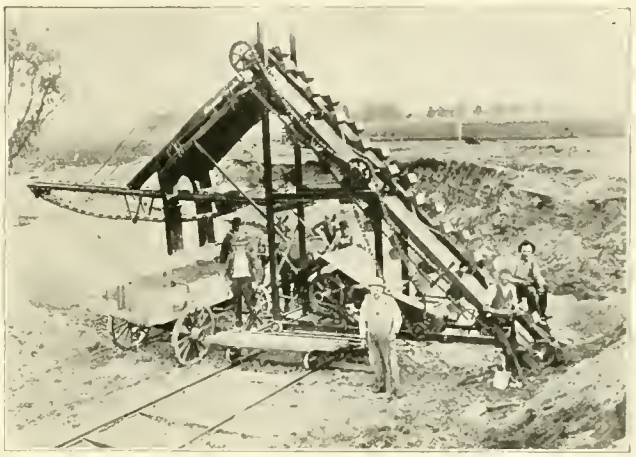

Calhoun County (Michigan) owns and operates four of these machines, and contractors own three others, making seven in the County.

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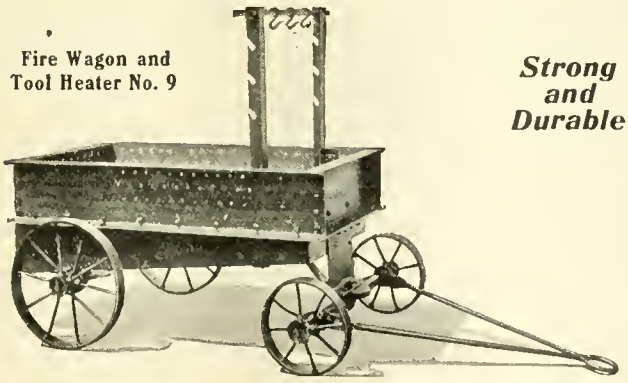

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their loads of aggregate and passed out onto the job. The use of the tractor train was successful because of the large quantity which it could haul at one time. The motor truck, however, served to fill in gaps and was used in handling the cement. This was advisable, as otherwise it would have been necessary to place the cement along the road at the same time that the aggregate was placed. In this instance, because of the great width of pile which the motor truck and tractor train spread, it was found desirable to pile the stone in a wind row on one side of the road and pile the sand as equally as possible in piles at distances of 15 ft. This arrangement allowed the loader plenty of room to move forward with its end over the sand pile so that it could be easily loaded.

Bates & Rogers on the Dixie Highway

A different system was employed by the Bates & Rogers Construction Co., Chicago, on the Dixie Highway. Here they used a 14 cu. ft. mixer delivering the cement, sand and stone in batches in motor trucks from a central proportioning plant. Their method was to divide the bodies of the motor trucks into compartments by placing swinging doors transversely to the body. Depending on the size of the truck, the body was divided into two, three or four compartments, each of which held a batch. The truck was driven to the loading bins, proper quantities of aggregate placed in each compartment and the truck then passed the cement storage shed, where the sacks of cement were thrown into each compartment. Just before the truck backed into the mixer the cement was emptied from the sack into the compartment of the truck. At the mixer the motor truck turned around and backed in, straddling the loading skip, the dump body was raised and the end gate released, allowing the first batch to run into the loading skip. The truck then pulled up sufficiently to allow the skip clearance. The skip was picked up and after discharging was again lowered, when the truck again backed in position for the discharge of the second batch. With a minute mix, very little time was actually lost by this system of handling materials provided it was possible to keep the trucks operating on schedule. However, this did not seem to work out as well as might be hoped as sub-grade conditions, slight delays due to poor roads, breakdowns at the unloading plant and other details resulted in delays to the mixer. However, the very difficult conditions under which this work was carried forward due to the sand sub-grade showed how successfully this system might prove under other conditions.

In DeKalb County, Illinois

In DeKalb County, Illinois, James O. Heyworth, Chicago, used two paving mixers holding 14 cu. ft. of concrete, equipped with power operated derrick. The loading plant in this instance consisted of two locomotive cranes carrying 1 yd. buckets, which handled the cement, sand and stone directly from the cars into bins, or else handled the aggregate into stock piles. The use of bulk cement proved eminently satisfactory. Industrial railroad cars in this instance passed under the bins and received their full quota of cement, sand and stone, there being two batch boxes to a car. The boxes were of the bottom dump type and were easily handled by a lever operating from the outside. The industrial railroad was laid on the shoulder. The boxes were picked up and swung into the loading skip by the power operated derrick. The Heyworth job offered to the visitor an opportunity to study a wonderfully balanced operation using two mixers, one on a short haul and the other on a long haul.

On Lincoln Highway in Illinois

A combination of the above methods was used very successfully by A. E. Rutledge, of Rockford, Ill., on his section of the Lincoln Highway, near Rochelle, Ill. Taking advantage of the old gravel road which was in place, he distributed the materials by truck prior to the tearing up of the sub-grade, placing them on the shoulders where they could be easily reached. Material was placed in piles at an interval of 400 ft., picked up by bucket elevator (see Fig. 5) and loaded into industrial cars. Cars were hauled by team. Material was hauled a maximum of 400 ft. to the mixer, where batch boxes were picked up, swung into

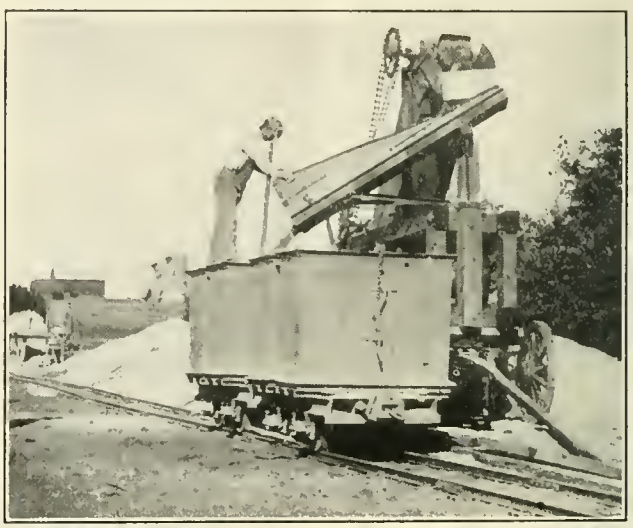

FIG. 5—BUCKET ELEVATOR PICKING UP STONE PILED ON ROAD SHOULDERS AND LOADING IT INTO INDUSTRIAL CARS.

place and dumped. Two distinct advantages accrued from this method—first, the material could be placed on the road before the grading was in progress, thereby allowing the trucks to use the road before it was disturbed, and, second, the distance hauled in cars was comparatively short. Mr. Rutledge stated that in 1920 he desires to extend the distance between piles from 400 ft. to 800 ft.

A Michigan Job.

On the G. L. Scharl job at Coldwater, Branch County, Michigan, the unloading was accomplished by the use of a locomotive crane. The yard was a fine example of careful planning. There were two tracks 400 ft. long on about 20 ft. centers. On one of these the cars of material were placed and on the other the sand and stone hoppers on railroad cars with the crane operating between them on the same track. The placing of the storage bins on flat cars so that they could be moved with the locomotive crane to any point where the aggregate was being unloaded proved very advantageous, as it was found impossible to get a switch engine to do switching sufficiently often to make possible the unloading of 500 cu. yds. of material per day without rehandling large quantities. The 2 ft. industrial railroad connecting the unloading yard with the mixer ran between the two tracks. When there

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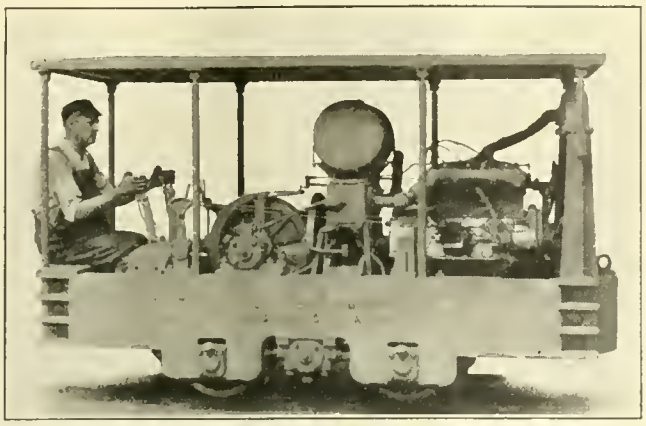

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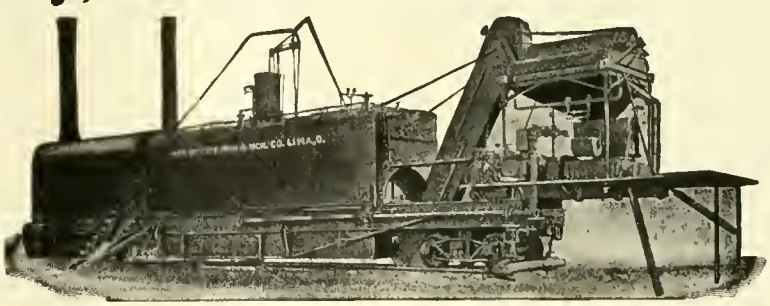

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was no opportunity to load the industrial cars the crane unloaded from the standard gauge equipment into a stock pile paralleling the crane track, thereby keeping sufficient stock on hand to insure against delays due to irregularity in the receipt of materials. The cement was received in flat bottom gondolas, protected from the weather by tarpaulins. The same clam-shell bucket that was used for unloading the aggregate picked up the cement and dumped it into the cement loading hopper. This hopper was stationary and was set up between the two standard gauge tracks over the industrial railroad. Although some question was raised as to the loss and the danger of loss by rain, experience proved that in the cement unloaded for about three miles of this work the greatest variation between the quantity delivered on the work and the invoice quantity of the cement company was the equivalent of six sacks per car and the average was considerably less than this. Two teams were used at the unloading yard for switching the industrial cars, and due to their ability to go to either end of a string of cars without loss of time this method seemed preferable to the use of a locomotive. The equipment used was the standard 2 ft. gauge track and cars and three and six-ton gasoline locomotives. The cars carried one batch box apiece with a capacity of approximately 55 cu. ft. They were handled in 15-car trains when the three and six-ton locomotives doubleheaded, and in ten-car trains when the six-ton locomotives operated alone. At the loa ling plant the proper quantity of stone was first put into boxes, then the cement was measured by being passed thru a cylinder holding 5 cu. ft. This was done by placing a 12 in. sheet metal pipe as the discharge from the hopper with a gate near the top and another near the bottom. The operator closed the bottom gate, opened the top gate, allowing cement to run into the cylinder, then closed the top gate and opened the bottom. This was then repeated to get the right quantity of cement per batch. A piece of canvas attached to the bottom of the cylindrical chute and to a hoop on the other end, which could be lowered into the car and raised in order to let the car pass, did away with loss of cement by wind. With the use of two locomotives doubleheaded it was possible for the smaller one to handle the empties back to the loading plant, while the heavier did the switching around the mixer. Prior to the arrival of the locomotive, however, such handling of loads and empties as was necessary at the mixer was handled by team.

The mixer used had a capacity of 28 cu. ft. of concrete. In other words, for every batch approximately 4 ft. of 16 ft. road was placed. The batch boxes were lifted from the cars by a locomotive crane (see Fig. 6), carried on caterpillars, swung into position over the batch hopper of the mixer and dumped in the same way with a clam-shell bucket. Traction for the mixer was furnished by the caterpillar crane. On this job it was proven that the machine had a capacity of 100 ft. of concrete road per hour. Some idea of the size of the machine may be obtained when it is appreciated that the wheels on which it moves are 4 ft. in diameter and have a 20 in. face, while the drum is 5 ft. 8 ins. x 4 ft. 9 ins. The paver, while comparatively light, being only two tone heavier than the Koehring No. 14E Paver, is of exceptionally sturdy construction. The motive power consists of a four-cylinder 5 x 7½ gas engine rated at 30 to 35 horse power. A special winding drum is mounted at the front and end of the framework for use in moving cars. The machine, like the other pavers, can be equipped with either a distributing boom and bucket or distributing spout.

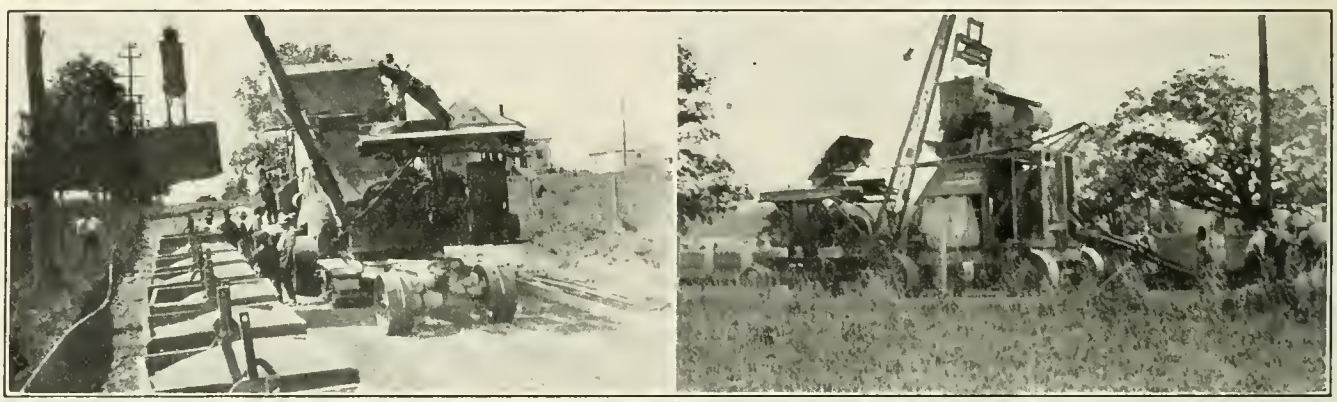

FIG. 6—BATCH BOXES LIFTED FROM INDUSTRIAL CARS BY LOCOMOTIVE CRANE AND SWUNG INTO POSITION OVER THE BATCH HOPPER OF THE MIXER, COLDWATER, MICH.

The foregoing is the major portion of a paper presented by Mr. Talbot at the recent annual convention of the Illinois Society of Engineers.

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EDITORIALS

WHERE CHLORINATION WOULD HAVE PREVENTED SICKNESS AND DEATH

The protection of human life is the highest form of civic enterprise in times of peace. Nothing is so discreditable to public officials as to be neglectful of the public health where measures for safeguarding it are generally well understood and widely applied. It is with the greatest regret that one learns of official carelessness or incompetence leading to the loss of life, but where such cases occur they must be cited as warnings to others with a disposition to be neglectful of official duties.

A certain city in western New York derives its public water supply from a grossly polluted river. The raw river water is admitted to the intake pipe line at a point far off shore, and pumped through the distributing mains to the consumers without filtration. Not until last summer was this water sterilized, and before sterilization was inaugurated the city experienced a severe water-borne typhoid fever outbreak. A break occurred in the intake line, at a point much nearer shore than the intake crib, where the pollution of the water was, of course, much greater than in the vicinity of the crib. As a direct result of admitting the highly polluted water to the city mains, typhoid, always prevalent in the city, became epidemic. During the epidemic there were 236 cases of typhoid, with 18 deaths.

There have been many water-borne epidemics of typhoid which could not very well have been anticipated, but in the case under discussion the epidemic was sure to come and was anticipated by the State Department of Health, which, lacking mandatory powers in the premises, labored for years with the city officials and the Chamber of Commerce, urging that the water supply be sterilized to safeguard the lives and health of the citizens.

The investigation of the epidemic plainly demonstrated the fact that had a chlorination plant been installed and in proper operation prior to this outbreak, as had been repeatedly recommended by the State Department of Health, the outbreak would not have occurred. It also developed that when a belated installation of a chlorination plant was made, there was an almost immediate checking of the outbreak and this undoubtedly prevented a much more severe outbreak from subsequent leaks in the intake line.

Thus chlorination once more demonstrated its efficiency. But the dependability of chlorination was established some years ago, and it is in the last degree unfortunate that the officials of this particular city did not avail themselves of a process of demonstrated worth which had repeatedly and urgently been brought to their attention as the very least measure they should adopt to protect the people of the city.

There is no longer any excuse for failure to sterilize all public water supplies of surface origin, and filtration is also highly desirable with all such supplies. Sanitary engineers have developed these processes, particularly chlorination, to a highly efficient point, and chlorination is easily within the reach of all communities where it is needed. Knowledge of the process is so widespread and so easily obtainable in detail, that it is now nothing short of criminal carelessness to distribute unsterilized water of surface origin for drinking purposes. Ground water supplies have also been contaminated so it is the first duty of every water works official to make sure that he is distributing a safe water. It is much better to sterilize in time than to be sorry after the epidemic has taken its toll in sickness and death.

OBLIGATIONS ARE RECIPROCAL

There has been considerable discussion of the rights and obligations of public employes since the Boston police strike of some months ago. It will be remembered that the thought of a strike by policemen was so abhorrent to the public that the Governor of Massachusetts was widely applauded in connection with the stand he took in this distressing occurrence. In fact, so universal was the commendation of the Governor that for weeks he was mentioned as a presidential possibility.

There can be no doubt that the public rebels at the suggestion of a strike of its employes, so the Chicago firemen, feeling themselves seriously underpaid, did not strike, but turned in wholesale resignations. Clerks employed in the City Hall at Chicago did actually "go out" for a couple of days.

The public is now taking its second thought with reference to these matters. It is perfectly natural and perfectly easy, seemingly, to strike a patriotic attitude and say that the public employe must not strike. It gives one a fine, inexpensive thrill to hold that policemen, firemen and others should never strike under any circumstances. That is, the thrill is inexpensive to the public, but the public employe pays for it, and right there is where the second thought on this subject comes in.

If it is held, and it is, that public employes are in honor and duty bound not to strike, then in all justice and conscience it follows that the public is in honor

and duty bound to pay adequate wages and salaries to its employes. This applies to all classes of public employes, whether city, county, state or federal, and to all grades, whether firemen, policemen or professional engineers.

Let us consider the case of the fireman, which we certainly can do without prejudice. Here is an able-bodied man, devoting his full time to the performance of an indispensable public service. With his intelligence and his physique he could earn very high wages in industry today, yet these splendid men have been paid only $1,800 a year by the great city of Chicago. They asked for only $300 increase in salary and it was denied them. Still, the suggestion that these men might strike or resign aroused a great show of indignation in many quarters. It must be remembered that the fireman's dollar buys precisely as much as the dollar of the organized, striking, skilled workman. If the latter compels the public to pay him more, then in all fairness the public employe must be voluntarily compensated for adjustments which continually decrease the purchasing power of his dollar.

Certainly we have no desire to contribute to the spirit of unrest. We have no sympathy with strong-arm tactics, but stand for the "established order," the good old plan under which individual merit was rewarded. But it is idle to expect that the guardians of the established order, the public employes, can remain loyal forever to old institutions which make no adjustments to meet a changed world. Sooner or later the individual public employe will choose between serving his family or the public, unless properly compensated, and no one has any right to expect that he will continue indefinitely to take from his family and give to the public. We doubt if public employes will do much striking, but they will drop public service for more remunerative forms of employment, unless they are raised from time to time like other wage-workers and salaried employes during these times of continuous economic readjustment. This will inevitably mean that many of the more efficient and ambitious will be lost to the public service.

THE MILITARY ENGINEER

In a recent editorial in this magazine engineers were urged to make use of the magazine formerly called "Professional Memoirs" in preserving to posterity a record of their professional activities directly connected with the recent war. Our point was that the belated war stories now being elaborated should be published where they will have the best chance of usefulness later on, while producing a minimum of irritation at the present time.

We are now in receipt of a copy of "The Military Engineer," formerly "Professional Memoirs." This is the journal of the Society of American Military Engineers. It is published bi-monthly at Washington Barracks, D. C. "Professional Memoirs" was a semi-official journal published for some years by the Corps of Engineers of the United States Army. During the war it suffered from neglect, but has now taken a new lease on life under a new name more appropriate to its mission and purpose.

As has been remarked before, the engineer plays a prominent part in the national defense. Without the aid of the engineer, military operations on the vast scale that is characteristic of these times would be impossible.

In peace times the government maintains a very small corps of a few hundred engineer officers which would be quite inadequate to meet the needs of a great war. Military duties will therefore of necessity fall upon civilian engineers on the outbreak of war, as was so recently demonstrated.

The federal government is now engaged in re-establishing the Officers' Reserve Corps, including engineers, on a basis similar to that of the pre-war period. A Society of American Military Engineers is now being established, to which all professional engineers, whether engaged in the recent war or not, are eligible to some grade of membership. The objects of the society are to promote solidarity and co-operation between engineers in civil and military life, to disseminate technical knowledge bearing upon progress in the art of war and the application of engineering science thereto, and to preserve and maintain the best standards and traditions of the profession, all in the interests of patriotism and national security. The principal instrument through which the society hopes to accomplish its aims is the journal, "The Military Engineer." The magazine is not to be operated for profit and it is not in competition with any other journal, as it occupies a field of its own. But it is not published by the government and must have the support of individuals who are interested.

All will agree that the purpose of the magazine is a most worthy one. The dues for membership in the society, which include subscription to the magazine, are very moderate. We bespeak for "The Military Engineer" the ungrudging support of all civilian engineers who have any liking for military matters. We suggest, especially, that all articles relating to engineering activities in the recent war and now released for publication be offered to this new journal, where they really belong. Almost every day we receive notice that some engineer is about to address a civilian engineering society on a topic which he should make the subject of a contribution to this new magazine. The engineering societies should now concern themselves only with matters of current interest and immediate application, and engineers should use "The Military Engineer" as a repository for matter which has no immediate interest to those in civil life, but which will have the greatest possible interest and value to engineers in military service 20 years hence.

Recent Experience in the Development of Brick Pavement Construction in the City of Chicago

By H. J. Firmer, Paving Engineer, Board of Local Improvements, City Hall, Chicago, Ill.

The city of Chicago, during the past twelve years, has used and experimented with many types of brick pavement construction. This period coincides with the writer's intimate acquaintance with paving construction in Chicago. During this time we have witnessed a great change in the volume and character of the vehicle traffic and likewise a wonderful progress in the use of materials and machinery in pavement construction. In making comparison with the results observed on many types of streets the writer has limited consideration to streets of fairly heavy traffic, built under uniform conditions and inspection and on a similar, more or less undrained, clay sub-grade.

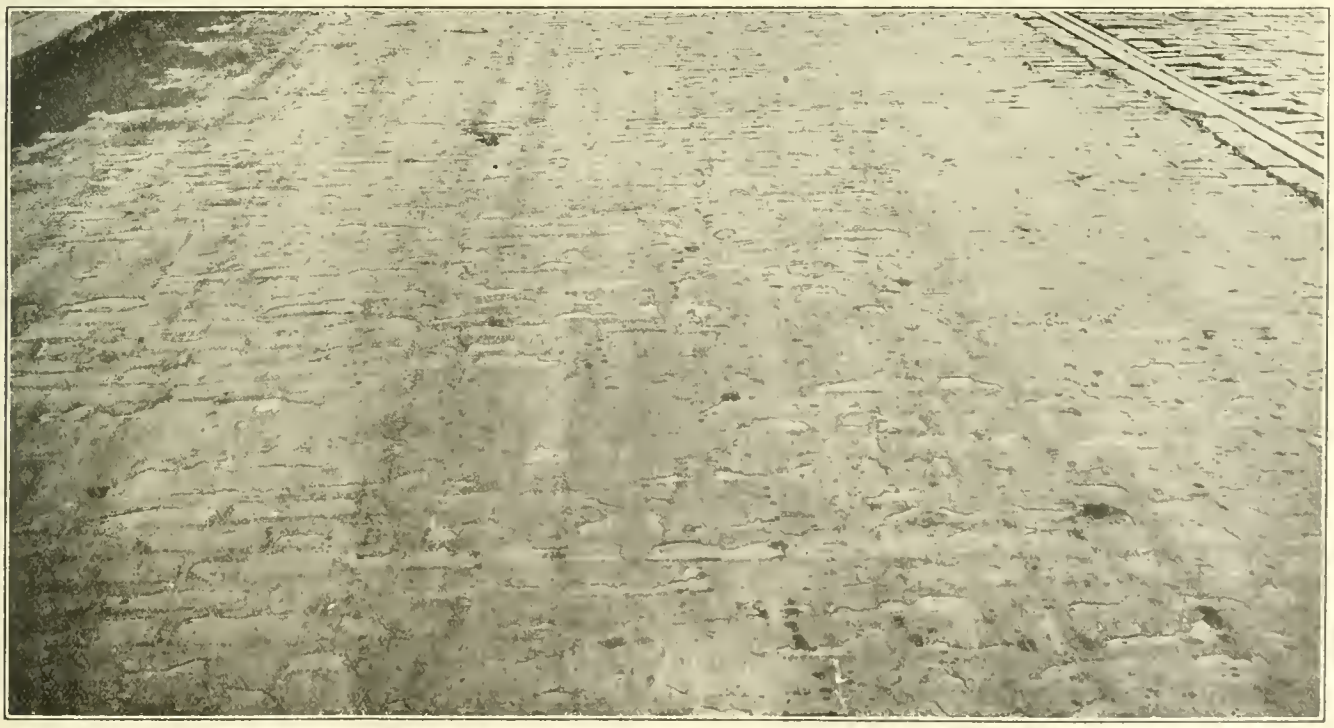
Prior to 1908 brick pavements were built on a foundation of crushed stone, hydraulic (natural and Portland) cement base, with a 2-in. sand cushion and fillers of sand, pitch (tar) or grout. On light traffic streets where some of these pavements remain, the grout filled pavements have kept the best surface; the others being cobbled and showing uneven settlement. The brick have borne the traffic well, very few fractured brick being seen.

Pitch Filler

In 1908 Higgins Road, from Milwaukee Ave. to Edmunds St., was paved with repressed brick on 2 ins. of sand and 8 ins. of limestone macadam base with a pitch filler. This pavement has settled badly and worn uneven, leaving the manholes above the present grade. Due to the fact that this has become a heavy traffic street, it will soon be replaced by a pavement on a 6-in. concrete base. It can be safely concluded from this, and other confirmatory experience, that under conditions obtaining in our city, a concrete base, or other rigid base, is necessary. In a city having a fixed grade to maintain, due to the location of car tracks and sewer manholes along the center line, and the necessity of cutting through the pavement to repair underground utilities, a rigid, self-supporting and easily repaired base is imperative.

Asphalt Filler

In 1913 N. Crawford Ave., from Fullerton Ave. to Milwaukee Ave., was paved with repressed brick on 2 ins. of sand and 6 ins. of 1-3-6 concrete, with an asphalt filler. This pavement is 42 ft. wide with a double track car line along the center. This street was the first, or one of the first, to have an asphalt filler and a vertical concrete curb, 7x9x24 ins. in section. This street, now seven years old, presents a good appearance, is generally even and smooth and still has the joints well filled, with a matting of the asphalt filler over the wearing surface in many places, as shown in the illustration. The concrete curb is in good line and to an even grade. N. Crawford Ave., south of Fullerton Ave., was paved the same year. The curb was sandstone and the filler was pitch (tar).



VIEW OF BRICK PAVEMENT, WITH ASPHALT FILLER, ON N. CRAWFORD AVE., CHICAGO, AFTER SEVEN YEARS OF SERVICE.

This Pavement is Even and Smooth and its Joints are Still Entirely Filled with the Asphalt. Note the Matting of the Asphalt over the Wearing Surface in Many Places, making the Pavement Practically Noiseless. This is a Moderately Heavy Traffic Street with Double Track Car Line. The Board of Local Improvements of the City of Chicago has Adopted Asphalt Filler as the Standard Filler for Brick Pavements on Streets and Alleys.

Cement Grout Filler

In 1917 Belmont Ave., from N. Crawford Ave. to N. Cicero Ave., was paved using wire-cut brick on a 1-in. mortar (1-4 mix) cushion, 6 ins. Portland cement concrete base and a standard (1-1 mix) cement grout filler. This pavement is very smooth, even and rigid. The mortar cushion was spread dry and the brick laid as customary. After rolling and culling, the bricks were well wetted before applying the grout filler. This was mixed by hand in approved grout boxes and applied in two periods. The first application was free flowing and served to set up the cushion and partially fill the joints, the excess water being absorbed by the bricks and cushion. The next application was of thick, creamy consistency and filled the joints and was lightly squeegeed over the surface. This pavement is practically a double monolith with a line of cleavage between the base and cushion. It is difficult to repair and construct, but appears to have kept a good, even, smooth surface. To care for the excess wear occasioned by the presence of car tracks, and due to the vibration and movement of the cars, and wear and shock caused by heavy vehicles turning off and onto the car tracks, it has been the writer's practice to lay four or five rows of granite blocks parallel with the rail. These are laid on a mortar cushion and filled with grout or with a mastic filler of bitumen and sand. In this way the brick pavement between the car tracks and curb is subjected to uniform traffic and naturally only uniform wear results.

In 1917 Irving Park Boulevard was paved from the Chicago River to Austin Ave. The work was done under two contracts, but the specifications were the same. The brick was wire-cut, laid on a 2-in. sand cushion on 6 ins. of Portland cement concrete. The filler was cement grout laid as previously described, except that a continuous grout mixer was used on one job and carts with revolving paddles on the other job. The mixing was well done and the filler carefully applied. Difficulty was had from the first with the 2-in. sand cushion. It was rolled and dampened but it was impossible to keep the sand from coming up into the joints. Frequently large areas were relaid, but the cushion would persist in coming up. The grout filler was applied in two applications. It was difficult to keep traffic off the street, which together with the constant street car traffic, no doubt, affected the setting of the filler. The following year defects appeared. These were generally areas having the top of the brick surface shattered. To the lay mind it appeared that defective brick had been used. When the brick were removed it was found that the cushion had come up and permitted only about ½ to 2 ins. of filler to penetrate the joints. This, of course, concentrated the pressure, due to expansion, along the top edge, with the result that the bricks sheared off. A pavement, structurally, can be likened to a long, thin column. The earth braces it on one side and gravity braces it on the other. As a column it resists the force of temperature. Now if any part is weak the column becomes eccentrically loaded and the stresses concentrated there tend to fracture the structure at that point. Obviously what happens when the joints are not uniformly filled with uniform resisting material, is either a fracture of the structure or a rise or blow-out in the top surface. It should be understood that while this pavement was laid in 1917, preliminary plans were made in 1914. At that time the writer was of the opinion that a mortar cushion should be used the same as he proposed and afterwards used on the Belmont Ave. job, previously described.

The advice of the brick publicity bureau, which promoted this work, was still tempered with love for the old sand cushion and apparently they really believed that a sand cushion under a rigidly bonded brick surface was necessary to give the surface "elasticity." It must be said, however, that they were faithfully reflecting the views entertained by many paving engineers of that period.

In keeping with the prevailing practice a sand cushion was used, with the result that this pavement will not develop the service the public has a right to expect. It can be definitely stated that a grout filler requires a mortar or grout cushion. If a grout filled brick requires any artificial foundation or base, that base should be a rigid base. The existence of many manholes in the typical city street introduces weak places which seriously affect a monolith surface laid without expansion joints.

Our experience with pitch filler was uniformly unsuccessful. In our climate with its wide range of temperature, it seemed impossible to produce a tar filler that will "stay put." It is either too soft in the summer and runs, or too hard in the winter, when it cracks and crumbles and disappears as dirt. At any rate it does not protect the upper corners of the brick and they soon wear rounded like cobble-stones.

Brick Construction is Durable

Despite the abuse of wrong cushions or fillers the individual brick has "stood up" these many years. Our testing requirements have on the whole secured a good quality of brick. The main thing to consider about brick is its uniformity. The smaller the range, regardless of whether the brick are soft, hard or medium, the better the wearing surface. An exceptionally hard or soft brick will produce unevenness and be a danger to the life of surrounding bricks. In general the quality of brick turned out is excellent and dependable. Likewise the concrete base is satisfactory. This leaves the cushion and filler as the remaining sources of weakness. With a grout filler we have learned a mortar cushion must be used. With an asphalt filler a mortar, sand or other fine inert material may be used for a cushion.

Where a grout filler is used the brick should present open, uniform joints. This is secured by using wire-cut lug or repressed lug blocks. Where an asphalt filler is used the closer the joint the better, provided the filler is applied sufficiently hot to flow and fill the joints. A repressed block is as satisfactory as a straight wire cut block, although it requires more filler.

Asphalt Filler Adopted as Chicago Standard for Brick Pavements

The function of a cushion is to give the individual block an even bearing on the uneven or "unsmooth" base. After securing this bearing the cushion should be kept undisturbed by a joint filler that will prevent motion up through the joints. Because of its adhesiveness asphalt is practically as good in this particular as grout. It has the further advantage of being able to "take up" any inequality or shifting of the cushion, by moving, under the influence of heat and gravity, up and down in the joints,

combining readily with the cushion to maintain a solid mass around the brick.

The function of the filler is to fill the joints flush with the pavement surface and maintain this condition. As stated before, it should be strong enough to prevent the cushion from working up and out. An asphalt filler should be applied quite hot and should be rapidly spread and worked into the joints by use of the squeegee. After this a light dressing of fine sand is spread to form a mastic and add stability. In practice one application is usually sufficient. The asphalt not only fills the joints but fills all light depressions or imperfections in the brick surface and because of the fact that there exists a reserve supply on the surface the joints are automatically kept filled flush with the pavement surface, as the illustration shows. The filler should keep water and other material out of the joints. Asphalt is both waterproof and water-repellant. Thus an asphalt filler is sanitary and clean.

An asphalt filler is easy to renew or repair. Its use permits repairs to the pavement surface with the minimum of loss of material and time. The street can be thrown open to traffic as soon as the joints are filled. This filler permits good foothold and traction on grades as high as 12 per cent. It is easily applied, a uniform product, and requires no expense to protect or cure. It forms an elastic cushion around each brick; minimizing the effect of impact; localizing the effect of shock, cracking or breakage, and eliminates the danger of cumulative expansion or contraction. It fills all slight surface unevenness and remains in place at the joint to keep the joint constantly filled to surface. Experience has proved all these things.

As a result of this favorable experience the Board of Local Improvements of the City of Chicago has adopted asphalt filler as the standard filler for brick pavements and alleys. In streets the brick are laid with the 4-in. depth vertical; while in alleys they are laid flat with the 3-in. depth vertical. In alleys with the wire-cut surface exposed the asphalt filler builds an excellent mat and thoroughly waterproofs the brick as well as the joints; a very desirable feature when one considers that an alley acts as a channel to carry water down the center. In view of our experience with asphalt in holding its position in the joint, we are now specifying a 1-in. cushion of sand, fine screenings or slag in place of the old 2-in. sand cushion or the more recent 1-in. mortar cushion. There is no objection to the cushion working up a little into the joints under the action of the roller since the asphalt combines with it readily and makes a durable mastic which effectively seals the joint from movement below.

Conclusion

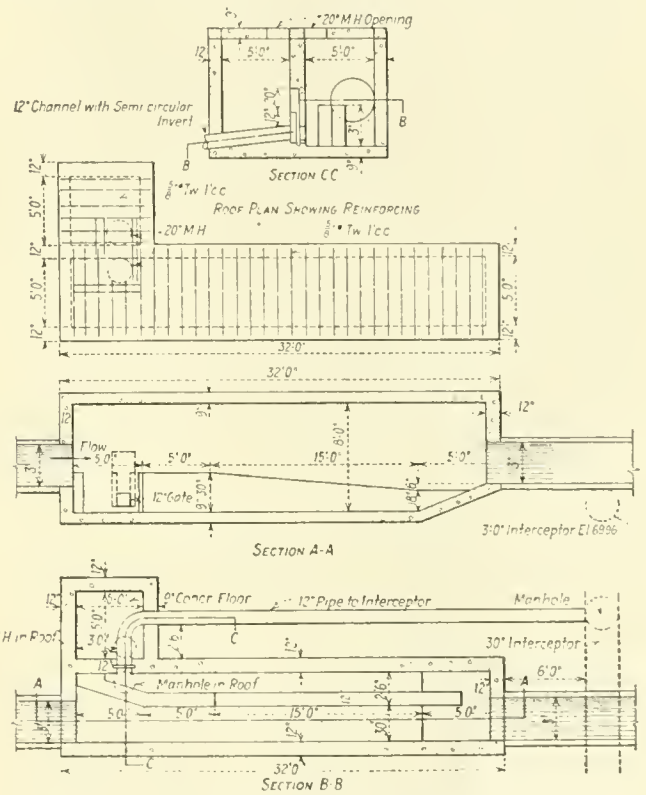
In conclusion, the writer believes the asphalt filler, with a 1-in. cushion on a concrete base, will give both satisfactory and permanent results. It is believed that where an asphalt filler is used, and where the pavement is properly maintained, no one can at this time predict the limit of life of well laid brick pavement. Practically all the maintenance required is cleaning the surface and applying a light squeegee coat of asphalt filler once in three, five or ten years, depending on conditions as revealed by the pavement in question. Recent experiments studying the effect of impact on road surfaces would seem to indicate that the presence of an elastic filler in the joints and on the surface to eliminate surface unevenness, is very desirable and can but add to the effective life and stability of the pavement.

GRIT CHAMBERS ON COMBINED SEWERS AT COLUMBUS, OHIO

By W. J. Weaver, Engineer in Charge of Sewer Construction, Columbus, Ohio

The problem of keeping grit out of intercepting sewers has always been a difficult one for the engineer to overcome. You will find, where intercepting sewers are used, that they are usually laid on very flat grades, and deposits of grit are bound to occur.

In Columbus, Ohio, the intercepting sewer is about



DESIGN OF GRIT CHAMBER ON STORM WATER SEWER IN COLUMBUS, OHIO.

8 miles in length, varying in size from 72 ins. down to 24 ins. in diameter, and the grade varies from .03 per cent. on the 72-in. to 0.15 per cent. on the 24-in.

Every year thousands of dollars are spent in removing deposits from this intercepting sewer, and while this work is being done all the sanitary sewage, above the point where the cleaning is being done, must be allowed to flow into the river. As this cannot be done while the river is low, the time is limited when such work can be carried on, and during the best part of the year the work must be stopped.

We have in Columbus 26 interceptor connections, all of which lead directly from the bottom of the combined sewer. These connections allow all the grit to be carried directly into the intercepting sewer, and the connections are being constantly clogged up by sticks, rags, tin cans, etc., and in order to keep them working properly they should be gone over every day in the summer and at least once a week in the winter.

In order to catch this grit before it enters the intercepting sewer, there was constructed in 1914 a grit chamber on the combined sewer, with a connection on the side leading to the intercepting sewer. After some studies on this grit chamber, and having made several changes in it, I finally made a design which I thought would do the work.

The first of the new design was constructed in 1916 and three others since that time. Two of them have not been put in use up to the present writing.

The accompanying plan shows the details of construction. These grit chambers vary in length and width according to the size of the sewer on which they are constructed and also on the amount of dry flow which they will carry. The stop boards leading from the chamber can be regulated for any quantity of dry flow, making the opening larger or smaller, as the dry flow increases or decreases.

The design was made to facilitate the cleaning. During rainstorms, when the flow is larger, a considerable amount of the grit will be washed out of the chamber directly into the river. Nearly all the grit will be deposited to the right of the dividing wall, or in the wide chamber, with a small amount of deposit in the narrow chamber. Most of the grit is deposited after a heavy rain and should therefore be cleaned out immediately after such a rainfall.

Cleaning is done by one or two men equipped with rubber boots and long-handled shovels. They enter the manhole over the grit chamber, and, standing on the dividing wall, throw the grit forward into the sewer outletting direct into the river. This, of course, will make a large dam, but the next rain will carry this grit directly to the river.

The frequency of cleaning will vary according to rainstorms. During the latter part of 1919 we kept a record of the approximate amount of grit removed in this way. One was as follows:

Aug. 22, 7 cu. yds.; Sept. 17, 5 cu. yds.; Oct 6, 6 cu. yds.: Nov. 10, 6 cu. yds.; Dec. 1, 9 cu. yds.; Dec. 9, 6 cu. yds., and Dec. 29, 10 cu. yds.—or 55 cu. yds. in the last six months of 1919, making an average of 7 cu. yds. per cleaning, at an approximate cost of $1.00 per cu. yd.

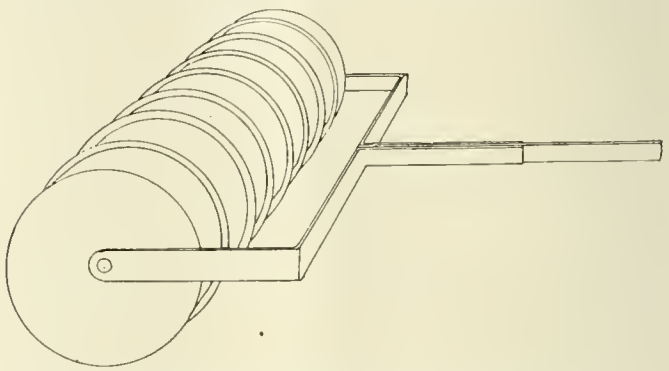
The grit chamber has proved very satisfactory in this city, and we contemplate the installation of one of these chambers on each of the old sewers having interceptor connections.

NEW DEVELOPMENTS IN CONSTRUCTION OF BITUMINOUS CONCRETE PAVEMENTS

By Theodor S. Oxholm, Chief Engineer, Borough of Richmond, Staten Island, New York

Last spring the author, at the invitation of Mr. A. Swan, Jr., C. E., City Engineer of Trenton, N. J., made an inspection of sheet asphalt pavements in that city which were laid directly on the concrete foundation without a binder course. Mr. Swan explained that by the use of a special corrugated tamper designed by himself he had corrugated the concrete base so deeply and uniformly at right angles to the traffic that there had been no creeping of the asphalt wearing surface under heavy use for two or more years, and a considerable saving in cost had resulted by leaving out the binder course.

In the Borough of Richmond the author has been using for some years concrete for pavement base composed of trap rock screenings instead of broken stone and sand, mixed six of screenings with one of cement. It was determined in a certain contract to use Mr. Swan's tamper. After about 300 ft. had been tamped, the assistant engineer, inspector and foreman on the work devised a roller made of a 2½-ft. section of telegraph pole, with bands of 1-in. round iron fastened around the roller and spaced 4 ins. on centers; a long pole attached, so that the roller could move easily, completed the outfit. The water was squeezed out of the concrete by a light roller such as is used for concrete pavement, and then as the concrete was beginning to set the corrugated roller above described was rolled across the base once for each section.



CORRUGATED ROLLER USED ON SCREENINGS CONCRETE BASE OF BITUMINOUS PAVEMENT IN BOROUGH OF RICHMOND, CITY OF NEW YORK.

The result was most gratifying, as a perfect series of depressions appeared, 1 in. deep and 4 ins. apart, uniform in character and extending the whole width of the base. It will readily be seen that this "washboard" surface will receive the asphalt or bituminous concrete and lock it so firmly to the base that creeping from lack of proper contact is prevented. It is thought that much of the creeping and rippling of the surface of bituminous concrete road surfaces is due to lack of proper contact with the base.

Proper Methods of Construction

Very often an old macadam road 5 or 6 ins. in depth makes a suitable base for a bituminous surface, provided drainage conditions are or can be made good. Care must be taken, however, in preparing the old surface, to make it as rough as possible, so as to prevent creeping of the new surface. The bond of the old pavement must not be broken, for if it is, its value is largely destroyed. Mostly all old macadam roads are now surfaced with road oil, which presents a smooth surface in patches. The best method of removing this oil surface appears to be the old-fashioned one of picking by hand lightly so as not to disturb the bond of the heavier stone. Some roads of this type which have been built by the author are quite inexpensive and are giving good service. They are edged with old stone paving blocks set in sand before the bituminous surface is applied.

The subject of drainage is an important one to the road builder. It is generally overdone, resulting in useless cost, or underdone, resulting in great damage to the pavement. It is not difficult for the engineer to tell with

approximate accuracy where drainage probably will be necessary, and make his preliminary estimates accordingly. Springs and wet places may be noted, and where changes of grades make additional cuts he should be prepared to underdrain when the work is under way and trouble is developed. The old-style stone drains, while efficient for a time, usually fill up in a few years and damage is sure to follow. The author uses 6-in. vitrified pipe with open covered joints in all French drains, which, with suitable outlets, will give good service for many years.

One of the most important pieces of road work in the Borough of Richmond which has been completed during the last few years is the paving of the Amboy road, 9 miles in length, running through the center of Staten Island and forming part of the main traveled route between New York and Philadelphia, Baltimore and Washington, and also New Jersey Coast resorts. Three years ago work was commenced on a contract for improving this road with bituminous concrete wearing surface 2 ins. thick, on a 6-in. concrete base. The specifications called for the use of Bermudez asphalt, as the traffic was very heavy. The pavement was laid 20 ft. wide and concrete edging 6 ins. in width was built up monolithic with the base. Four-foot earth wings were graded down to a uniform ditch along the sides, except where passing through built-up sections where curbs and gutters already existed. The total cost of the work was $330,000, at pre-war prices, and after two years of service the appearance of this pavement is excellent, and practically no repairs have been made. On the first section of about 3 miles it was noticed during the suspension of work for the winter that some transverse cracks had appeared; it was therefore decided to cut ¼-in. joints across the pavement as it was being laid, 300 ft. apart, and fill with asphaltic cement. On the balance of the work this was done, and no more cracks have occurred.

As the bituminous material for the wearing surface is brought onto the street it is dumped onto the base and shoveled into place for the rakers. The shovelers tread down the hot mixture so that it becomes compressed before the roller reaches it. This causes an unequal density in the completed work and tends to make the pavement uneven. One method of avoiding this is to have the entire amount of each load of hot mix shoveled and spread in adjoining locations. This causes the breaking up of the portion treaded down and the rakers soon reduce the heavier portions to a uniform service ready for rolling. Proper protection to the edges of bituminous pavements should always be provided, but often are not. If old paving blocks are not available, either concrete edging or a steel angle iron of proper design, and anchored into the concrete base, will protect the pavement from undue wear. The failure to provide this protection soon results in an 18-ft. road becoming reduced to 16 ft. in width, and the narrower it gets the more rapidly the pavement deteriorates.

Bad Practices Which Should Be Eliminated

The placing of a bituminous concrete wearing surface on top of an old penetration macadam road as a base is sure to result in serious damage to the pavement. Wherever an excess of road asphalt exists in the original pavement it will soften the new wearing surface over it and disintegrate it within a year.

While a liberal use of the oil burner in preparing the foundation will improve this condition considerably, yet in the author's opinion this form of old pavement provides a very poor base for a hot mix wearing surface.

Where an old waterbound macadam pavement has been covered with 3 or 4 ins. of penetration macadam, and it is desired to place a new wearing surface of bituminous concrete, the author has had good results from removing the penetration pavement entirely, and forming a new crown and repairs to the old macadam, with new ¾-in. stone and screenings.

One of the most important defects in bituminous pavements, and one which is undoubtedly caused by the great loads being carried by enormous trucks, is a pushing forward of the top of the wearing surface, creating waves and ripples that sometimes are so marked that the bituminous material has to be removed and replaced. In the opinion of the author this is caused by requiring a too high penetration test in the asphaltic cement. This has usually been placed at from 50 to 70 in cities near New York, but latterly the Borough of Manhattan has gone to the other extreme and laid pavements at penetration of 30. While the author believes that cracks in bituminous surfaces are preferable to ripples, and can be more economically repaired, yet a medium hardness should be called for. He suggests 45 to 50, and has been laying considerable pavement at 48 during the past summer.

Bituminous pavements adjoining the rails of street car tracks should be protected from disintegration caused by vibration of the rails. In many cities this has been neglected.

It is impossible properly to compact the bituminous material under the head and flange of the rails. The vibration during the passage of cars destroys the bond of the bituminous material, allowing surface water to enter the space thus formed, resulting in the final disintegration of the pavement. This defect may be obviated by the use of stretcher courses of stone blocks along both sides of the rails. The width of the stretcher area should be sufficient to permit the ordinary rail repairs to be made without cutting into the bituminous pavement.

Another method of construction is to pave up to a steel angle iron laid parallel to and adjoining the rails, the pavement then being practically independent of the railroad tracks.

The proper way for an engineer to find out defects in his own practice is to visit periodically other localities. He will generally find some conditions better cared for than at home, and sometimes may find that he has solved a certain problem better than his brother engineer.

The foregoing paper by Mr. Oxholm was presented at the recent annual meeting of the American Road Builders' Association.

MANY PROSPEROUS ILLINOIS VILLAGES STILL UNSEWERED

While Illinois is probably as progressive as any state, it still has hundreds of prosperous but unsewered villages. Poverty is almost unknown in these agricultural villages; nearly every family is in fairly comfortable circumstances. Here is a great opportunity for promotional work which will benefit the public.

The following interesting data on the sewerage of small towns in Illinois are from a paper by Mr. M. C. Sjoblom, Assistant Engineer, Illinois State Department of Health, presented at the 1920 annual meeting of the Illinois Society of Engineers:

The following data, though not exact to the last town, give the approximate number of towns sewered and without sewerage. The population figures given are taken from the 1910 census. A number of the towns have doubtless grown in population so that they do not now fall within the classes in which they are placed. However, this simply makes conditions worse than actually presented here.

Population	No. Villages and Cities	Have Sewers	Without Sewers
Below 500	416	0	416
Between 500-600	87	2	85
Between 600-700	69	4	65
Between 700-800	53	2	51
Between 800-900	29	1	28
Between 900-1,000	37	3	34
		12	679

The situation among cities having a population over 1,000 is as follows: There are a total of 189 cities which have sewerage systems. Of these cities there are 87 which have a population of 4,000 or over so that there are only 102 cities between 1,000 and 4,000 which have sewerage.

There are 160 cities and villages with populations of over 1,000 which are without sewers. This list may be classified as follows:

Population	No. of Cities and Villages without sewerage
1,000-1,100	32
1,100-1,200	24
1,200-1,300	12
1,300-1,400	14
1,400-1,500	11
1,500-1,600	10
1,600-1,700	6
1,700-1,800	0
1,800-1,900	6
1,900-2,000	6
2,000-2,500	20
2,500-3,000	11
3,000 and above	8
	160

If a detailed study were made of the entire state, it would doubtless be found that the above figures indicate conditions far better than actually exist. Such a study would doubtless show, also, a large number of the towns sewered but partially, which are credited with sewers, and many others to have systems which are not worthy of the names of sewerage systems.

THE PRESENT HIGH COST OF MONEY TO PUBLIC UTILITIES

By Dow R. Gwinn, President and Manager, The Terre Haute Water Works Co., Terre Haute, Ind.

In these days of extremely high cost of living, when the cost of provisions, clothing, coal and other commodities has reached a high altitude, the cost of money has also materially increased. The average citizen who has observed the great advance in prices of groceries, meat, clothing and shoes, has probably failed to note that the cost of water, gas, electricity and street car service has not advanced in the same proportion.

And while some workmen have had a period of wild extravagance, indulging in $15 silk shirts, the average salaried man has been so busy trying to stretch his income to meet the rising cost of living that it is not surprising that he has not had time to consider the difficulties under which the public utilities are struggling. The word "struggling" is used after due consideration.

Cost of Water Works Operation

While the title of this article indicates that it will deal with cost of money, the author will take the liberty of stating that a compilation made by him shows that since 1914 the average increase in the cost of 29 items entering into the operation of a water works plant was 86.7 per cent. The average increase in the cost of labor at the Terre Haute plant since 1914 is 63 per cent. The increase in common labor has been approximately 100 per cent.

As a matter of fact, cost of operation does enter indirectly into the cost of money, for when there is a big increase in cost of operation without an increase in gross earnings, there is a reduction in net earnings which may materially affect the attractiveness of bonds. And if bonds are not attractive to the buyer, he will expect a larger discount, which means a higher cost to the utility for the money he rents.

Where the utility must filter and sterilize water, the cost of operation is subject to an unusual increase. It is necessary to maintain the standard of purity regardless of cost or dividends.

The company whose bonds matured since the United States entered the great war was extremely unfortunate. The necessity for money for war purposes was so great that the rate of interest on Liberty bonds was raised again and again. When the investor can buy 4¾ per cent. Liberty bonds at less than par, he has no interest in the average utility bond, unless the security is ample and the return much higher than from government bonds.

Re-financing

The author is familiar with the re-financing of a water company whose 4½ per cent. 20-year bonds matured last June. There was approximately $1,000,000 outstanding. It was necessary to issue $1,035,000 6 per cent. 5-year securities, which were sold at 94, or at a discount of 6 per cent. The company is required to pay into a sinking fund, out of surplus earnings, $20,000 per annum for retiring the securities.

The annual interest charge was increased $17,100; that is, from approximately $45,000 to $62,100. The discount, when amortized over the 3-year period, amounts to $12,420 per annum, making an increase in the cost of money to the company of $29,520 per annum.

However, there were other costs in connection with the issue of the securities, such as attorney fees for preparing the trust deed and other papers, traveling expenses, revenue stamps and printing; the fees to the State amounted to $2,087 for authority to issue securities. The company assumed the income tax up to 2 per cent. on the bond interest.

Outside of these extra costs, which were kept at the minimum, the cost of money to the company is 7.63 per cent. Including the additional expense, the cost is almost 8 per cent.

In five years from the date of issue the whole program must be repeated. It is to be hoped, however, that the cost of money at the time of maturity will be lower than at present. Fortunately for the company, the Public

Service Commission authorized an increase of rates, which has been a great help, although the increase was not as much as was asked for or what the company thought it was entitled to.

Rate for Interest and Return

To show that the case referred to is not an unusual one, the author will state that public utility securities have been offered recently to yield the investor in the neighborhood of 8 per cent. This would mean that the cost to the utility for money would be considerably more.

When a utility must pay 8 per cent., and in some cases 10 per cent., for the use of money, how can it be expected to do business and furnish satisfactory service on a 7 per cent. rate of return?

The securities of the Toledo Traction, Light and Power Company were recently offered to yield the investor 8 per cent. It means that the cost to the utility would be even more than that high rate.

The securities of the Cincinnati Gas and Electric Company have recently been offered to yield the investor over 8 per cent.

The Brooklyn Edison Company also issued some securities that will be due in 1930, which were offered to yield the investor 7 per cent.; the discount and expense must be taken into account to get the actual cost to the utility.

The author has a list of about a dozen large utility concerns, the securities of which were offered to yield 7.55 per cent., 8, 7, 8, 7.8, 7.75, 7.75, 7.75, 7.5, 7.18, 7.5 and 7.8 per cent. This will give an idea of the yield to the investor, but it should be borne in mind that the additional cost to the utility is greater than the figures mentioned.

The additional cost depends on the money market, the life of the bonds or other securities, the standing of the utility, the record of earnings, etc., etc. The banker who buys the securities must maintain a selling organization, and there is the expense of investigation, examination of properties, audit, legal opinions, and also overhead expense.

A prominent financial writer, in a recent review and forecast, stated:

"Careful attention, however, should be given to fare and rate regulation and limitation, which has caused the downfall of some of the strongest companies in the country during the past few years of rising costs and restricted incomes. Many traction companies have been crucified on the altar of political stupidity."

Some Relief to Traction Companies

Some traction companies have been granted relief. It is shown in a statement recently published that fares have been increased in 460 cities. The 10 ct. fare now prevails in 59 cities. Unfortunately, 48 companies went into the hands of receivers in the year 1919, and in the past three years 98 companies were involved in bankruptcy.

Property that is dedicated to the use of the public should be treated fairly and liberally, otherwise capital will seek other investments. Unless the rate of return is such as to attract capital, the property cannot be improved and needed extensions made. The result is that the public suffers. The public is willing to pay reasonable rates for good service. An inadequate rate of return not only hurts the utility, but it hurts the public.

A Sensible View of Financial Matters

The author was interested in a decision rendered April 18, 1916, by the Railway Commission of Wisconsin, in the case of Peter S. Bogard vs. Wisconsin Telephone Company. Here are a few extracts from the decision which show the sensible way the Wisconsin Commission looks at these financial matters:

"The cost at which capital can be had depends upon the market rate for money in similar undertakings. * * * During the past decade the cost of capital and of the other elements mentioned for public utilities generally, which are operating under conditions that may be regarded as normal, has ranged from about 7 per cent. to more than 9 per cent. on the fair value of the plants and their business. * * * When the net earnings available for returns have amounted to at least twice as much as the interest charges on the bonds, the cost of obtaining the money has not often been less than about 6.5 per cent. When that part of the capital, which is thus comparatively well secured, costs as much as this, it is rather obvious that the balance of the capital over and above that part which is thus represented by the bonds, must cost a great deal more. In fact, experience shows that for the latter part the cost is often from two to three times as great as for the former part. This is certainly true when the investment is based on commercial considerations alone. The cost of the capital needed is a part of the cost of the service that in the long run must be borne by the consumer if the service is to be furnished. This cost, like most other costs, is fixed in the open market by economic forces over which individuals and companies have little or no control. * * * In many of its decisions, where the conditions were normal, the Commission has found the reasonable rate of return to which utilities should be entitled to be from 7 to 8 per cent. of the fair value of the property and business. We believe that in the present case * * * the latter rate of return is fully justified."

It should be noted that the decision from which the extracts were taken was rendered April 18, 1916, or nearly four years ago, when the demand for money cannot be compared with the present great demand and high cost.

Liberal Treatment Is Absolutely Necessary

Water companies and departments have been given some relief, but in a general way it would seem that the relief has not been in proportion to the rate of increase in the cost of operation and in the cost of money.

In justice to many commissions it may be stated that they are making a conscientious effort to give the necessary relief, and it is to be hoped that the vision will be broad and clear; that the Public Service Commissioners will realize that if service is to be continued and of proper standard, that liberal treatment in the way of return is absolutely necessary; that in order to borrow money to make extensions and improvements it is necessary for the utilities to make a reasonable profit in addition to mere interest; that the public should be protected in the way of securing service as well as in the matter of rates; that the public will not be benefited by driving private ownership from the utility field; that with money costing 8 to 10 per cent. and a rate of return of only 7 per cent., the end will not be long postponed.

Extracts from Liberal Commission Views

In conclusion, extracts from several Public Service Commission decisions and also one report will be given.

Judge Thomas M. Cooley, first Chairman of the Interstate Commission, in the report for 1888, page 22, gave expression to the following:

"The public can never be in the wrong in demanding good service when fair rates are considered; an enlightened public sentiment will never object to fair rates when it is understood that good service is conditional upon them."

The following is an extract from a decision of the California Railroad Commission in City and County of San Francisco v. Pacific Gas & Electric Co. Decision No. 4736, case No. 839, P. U. R. 1918-A, January 31, 1918:

"The Commission, in fixing a rate of return, must be liberal, lest too strict a portion result in turning capital to other fields of enterprise. In this case we shall recommend rates which to the best of our judgment will yield to the company a return of 8 per cent. on the fair value of the property used and useful."

Wisconsin Railroad Commission in Re: Milwaukee Electric Railway & Light Co., P. U. R. 1918-A, February, 1918, 798, appears the following:

"Increases in rates necessary to enable a public utility efficiently to perform its public obligations and to render public utility should not be allowed to decrease owing to abnormally high operating costs until a point is reached where a question of difficulty to meet fixed charges is seriously presented."

In the case of the New York Public Service Commission, 1st District, Re: New York & North Shore Traction Co., No. 2217, decided January 10, 1918, P. U. R. 1918, February, 893, it was stated:

"The State, through the Commission, endeavors to see to it that upon the business done by the company, rates reasonable for the service and productive of a reasonable revenue, are charged. Otherwise the company must go out of business or rely on the charity of investors. It is obvious that any business, to continue, must have a revenue that will do more than meet the mere cost of currently running the business. * * * There is no way of getting something for nothing over a long period of time."

In a decision by the Oregon State Public Service Commission, handed down January 5, 1918, pertaining to the Portland Railroad, Light and Power Company, it was stated as follows:

"It is time for the public to realize that the powers conferred upon public service commissions, thoroughly tested and upheld by the courts, are ample for the protection of the public against all the evils from which they suffered in the past. * * * It is time also to realize that good service can be obtained only by just and equitable treatment. * * * No starved horse ever pulled a heavy load. * * * The utilities have been deprived of the power to make unjust profits. They must also be protected against unjust losses. * * * If a utility is driven into a position where its credit is impaired and it can obtain money for operations and extensions only at unreasonable cost, the public must share the loss."

The foregoing paper by Mr. Gwinn was presented before the recent annual meeting of the Illinois Section of the American Water Works Association.

FUNDAMENTAL CONSIDERATIONS AFFECTING CONCRETE PAVEMENT DESIGN

The article with the foregoing title, contributed to the February issue of Municipal and County Engineering by S. T. Morse, city engineer of Carlinville, Ill., has attracted favorable comment. Three of the letters to the editor, commenting on the article, follow.

Irving W. Patterson, chief engineer of the Rhode Island State Board of Public Roads, writes:

"The article impresses me as one of the most interesting technical articles upon the design of concrete pavements that I have read. It seems to me, however, that a feature of design which might be covered more fully is the relationship between depth of slab and subsoil conditions. We pay the greatest attention to the study of subsoil conditions. This feature of our work is described to some extent in an article by me appearing in the issue of Engineering News-Record, published Dec. 20, 1919. It seems to me that treatment of unfavorable subsoil conditions is one of the most necessary features of design of any type of pavement. I appreciate the fact, however, that the treatment of subsoil defects may not be considered properly as a feature of pavement design. It seems to me, however, that the most careful design of the pavement proper is of little avail without an equally careful study of subsoil conditions."

H. K. Bishop, chief engineer, Indiana State Highway Commission, writes:

"I have read this article over carefully and I believe that Mr. Morse has an interesting article and has brought out some very good points.

"Due to the fact that my graduation from college dates back about 25 years, I have had a little difficulty in following all of Mr. Morse's mathematical deductions. However, I believe the result obtained as shown in Table 1 at the foot of page 65 gives the thickness of pavement consistent with our experience.

"Mr. Morse's conclusion that we are coming to a 1:1:2 mix may be right, but I have some doubts. It would seem to me that the improvements made in the mixing and finishing of concrete will enable us to use the leaner mixes and obtain good results. The use of a good type of finishing machine, with a proper tamping device, enables the use, I believe, of a slightly leaner mix to obtain equal results.

"The author in Table 1 gives the proper thicknesses for a 16-ft. concrete road with a 1:1½:3 mix as 8.17 ins., and for a 20-ft. road as 10.4 ins. Interpolating for an 18-ft. road, we would have an average thickness required of something over 9 ins. While this conclusion would meet with our approval, we are governed by other considerations.

"Mr. Morse's theory assumes that we have plenty of funds. Practically, we are usually limited on the width and thickness of pavements to what public opinion will stand. In Indiana we are constructing one-course concrete roads, 6 ins. at the sides, 8 ins. at the center and 18 ft. wide, giving an average thickness of 7 1/3 ins. These roads are costing us from $35,000 to $40,000 per mile. This seems to be about all the public will stand for at this time.

"It would seem to me that the character of the foundation and treatment by under-drains might possibly have a little more bearing on the thickness of the slab than that allowed for by Mr. Morse's formula.

"Where we have been unable to get satisfactory sub-grade conditions the thickness of slab which we are building under the traffic conditions which we have has given good results. I admit that it would be better to have the additional thickness recommended by Mr. Morse's formula, but I doubt if we could persuade the authorities of this State to increase the cost due to this additional factor of safety.

"We are, therefore, struggling along, trying to improve the sub-base conditions and other factors which will allow us to use a thinner slab. It has been our experience, and I think will be corroborated by Delaware, that a uniform sub-grade obtained usually by ploughing to a depth of 10 or 12 ins. will eliminate the longitudinal cracking.

"Theoretically, I think we are wrong in our design of roads of this type. There is quite a desire to standardize road construction, and slabs of uniform thickness are adopted irrespective of subsoil conditions or consideration of the traffic, both present and future.

"The standard design requires less labor in the prepration of the plans, which is perhaps a greater convenience. We attempt to standardize the design of the road metal itself and prepare our foundations where necessary so that conditions of sub-grade are equal. This process overlooks, however, the question of traffic altogether.

"I believe the practice in most states is to standardize their designs, although some states allow a different thickness for different traffic conditions. In Indiana our variation in traffic is not so great as in some of our sister states and a consideration of this is less important.

"In conclusion I wish to say that I think Mr. Morse has brought out some good thoughts here and has treated this subject in a thoroughly scientific way. I believe that his conclusions are on the safe side and that where practicable the results obtained from Equation No. 5 in the rational design of the central thickness of concrete pavement slabs should be followed."

Mr. W. D. P. Warren, of Miller, Holbrook, Warren & Co., Civil Engineers, Millikin Bldg., Decatur, Ill., writes:

I have read the article, "Fundamental Considerations Affecting Concrete Pavement design," by Mr. S. T. Morse, published in the February, 1920, issue of Municipal and County Engineering, and find his discussion one which adds much of interest to available data on this important subject.

He very forcefully directs the attention of the profession to the fact that concrete pavements should be designed, and that such design should be governed by certain known engineering principles and the application of such local data and information as may apply. While there may be other factors which will affect the design, I believe the considerations stated are of such vital importance that recognition of them will go far toward the solution of some of our present paving difficulties.

The fundamental considerations will be discussed briefly as follows:

Foundation

The writer has observed over a period of years that a rigid slab of concrete, such as a concrete sidewalk, a concrete pavement, or a monolithic brick pavement, is subject to longitudinal cracks, and that such cracks develop to a greater degree as the width of slab increases.

We avoid this in concrete sidewalk construction by cutting our blocks, usually specifying that blocks only 4 ins. in thickness shall not exceed 5 ft. in width.

Experience in sidewalk construction is that a 4-in. walk over 6-ft. in width will invariably develop longitudinal cracks.

The same principle will hold true in concrete pavement construction where the vertical movement of the earth at the sides, due to the effect of moisture, will cause the slab to be subjected to longitudinal stresses. The allowance for this stress in design may be made either by increased thickness of slab near the center, depending upon the width, or by use of a longitudinal joint. The construction of such a joint certainly has some objectionable features, although not serious on certain widths of pavements, when it is considered that separation of lines of vehicles is now advantageous.

Weight and Speed of Moving Loads

Consideration of the pressures due to impact have been less essential with some other types of pavements, but with the concrete type impact should receive careful anaylsis and proper allowance should be made for it.

Recent experiments conducted along these lines generally bear out the values submitted.

Strength of Concrete

Regarding the preference of a 1:1:2 mix over a 1:2:3, it is thought that possibly a 1:2:3 mix will generally be found more practicable. It is the belief of the writer on this point that tougher aggregates and scientific grading will secure a satisfactory strength of concrete and, in fact, an economical strength.

Width of Pavement

This was discussed briefly under the heading of Foundation, and it is desired now to direct attention again to this important detail of design.

Engineers as a rule recognize the fact that any type of pavement will require regular maintenance. Practically all our state highway departments and most of our cities of any size have recognized the necessity of constant, well directed maintenance, and yet we are still endeavoring to design pavements which will require little or no maintenance.

Consideration of this fact should be of great value just here. Shall we undertake so to design and construct a pavement in certain details that it will positively require maintenance? This has been done in practically every type of engineering structure, and, as an example, we have in the elimination of our transverse joints in concrete pavements, and the maintenance of resulting transverse cracks, admitted the wisdom of such practice. Shall we now design concrete pavements of certain widths and in certain locations with a longitudinal joint and assume that we can either properly protect the joint or maintain it at an economical cost?

Conclusion

The writer feels from a study of Mr. Morse's article that he has given this subject much thought and that his discussion should enable the profession to obtain a clearer

understanding of the considerations affecting the design of concrete pavements.

I have had opportunity to observe the action of concrete pavements under varying conditions and believe that recognition of the fundamental principles that govern concrete as a structural and paving material will enable us to build concrete roads and streets at a reduced cost regardless of the present high prices of labor and material.

NEW INSTITUTIONAL SEWAGE TREATMENT PLANT AT WEST FALLS, VIRGINIA

By George L. Robinson, Consulting Engineer, 37 East 28th St., New York City

The accompanying drawing indicates a sewage disposal plant which was designed by the writer and is now being installed for the School of the Sisters of Perpetual Adoration at West Falls, Va.

This plant is interesting chiefly because its design was necessitated by the restricted grades. The stream into which the effluent flows is at such an elevation with relation to the new buildings that it prohibits the use of sprinkling beds.

There will be about 300 children at this school—mostly boarders—and the sewage production is estimated at about 10,000 gallons a day.

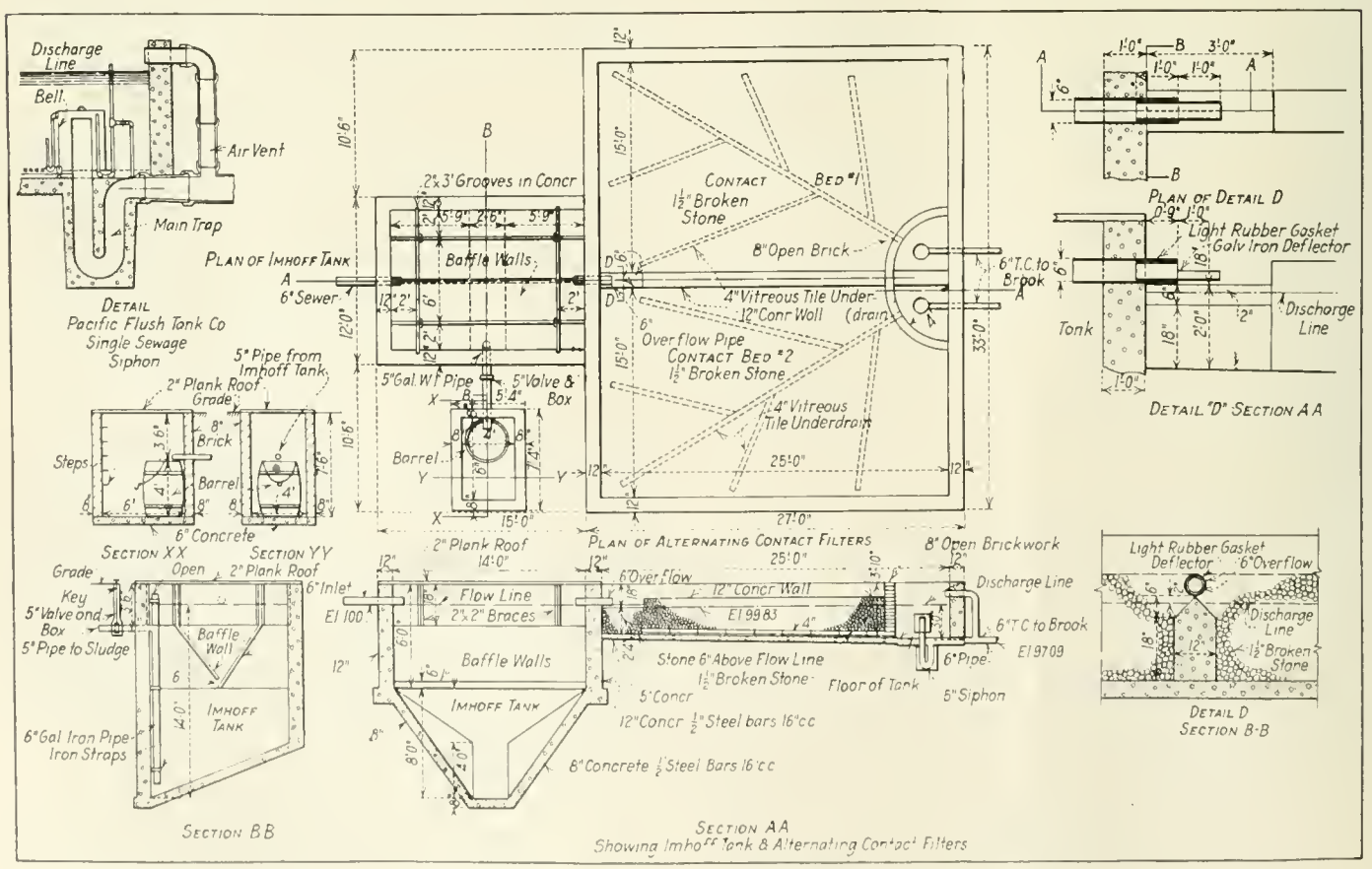
The plant consists of a modified Imhoff tank, the sludge compartment sloping to one side and the cast iron sludge removal pipe being valved in such a way that the sludge, when it accumulates, can be turned off into a large barrel contained in a masonry pit adjacent to the tank; the sludge being removed in the barrel to some point on the farm where it can be buried or used for fertilizing purposes.

The effluent from the Imhoff tank passes over into either of two contact beds. The control of the flow into either or both beds is shown in the detail drawing. The arrangement consists of galvanized sheet iron half pipe cut away from a section of full pipe. This piece is inserted into a 6-inch overflow pipe from the tank and is held in place by a light rubber gasket. By tipping the half pipe in either direction the flow from the Imhoff tank will pass into either of the contact beds. By removing this galvanized half pipe entirely the flow will strike the angle on the division wall so that the water will pass into both beds simultaneously.

Each contact bed is provided with an automatic Miller siphon. These siphons are not related and they discharge independent of each other. The overflow arrangement from the Imhoff tank permits the siphons to operate in rotation or continuously.

Although no sterilization outfit for the effluent is shown, it is understood that a chlorination plant may be installed at a later date if necessary.

The dimensions of the Imhoff tank and the contact beds are shown clearly on the drawing and follow the usual practice as to capacity.



DETAILS OF DESIGN OF A NEW INSTITUTIONAL SEWAGE TREATMENT PLANT AT WEST FALLS, VIRGINIA.

DESIGN AND OPERATION OF MOVABLE CREST DAMS

By Wm. G. Fargo, Fargo Engineering Company, Jackson, Mich.

If in the construction of dams, solid overflow weirs or rollways are used, there must be provided a freeboard height at the dykes, embankments, abutments, power houses, and other adjacent structures, equal to the maximum expected flood rise, plus a safety margin. The flowage land purchased must also extend above such expected flood contours, otherwise damage claims arise. Moreover, if floods are allowed to rise over a spillway crest, this will operate to reduce at such times the head of the next dam above, if it is close by. It is therefore frequently important to provide large waterways through dams by means of gates and similar devices.

Means for lowering the crests of dams and controlling openings through dams may be for the most part categorically placed in the following leading classes. It should be borne in mind that there are various gates combining two or more of the various elements or principles involved.

Classes of Gates and Movable Weirs

I. Needle dams
II. Slide gates
  (a) on crest
  (b) deep sluices
III. Pivoted or hinged gates and flashboards, including:
  (a) Various "bear-trap" types
  (b) Tainter (or sector gates) and drum gates
IV. Rolling gates, including:
  (a) Cylinders
  (b) Shutters of polygon section mounted between large wheels or rollers which traverse inclined tracks.
V. Siphon spillways.

Means for Operating Gates

Small gates are opened and closed manually, as are also gates of considerable size, through the interposition of trains of gears or equivalent devices. Where quick operation is desired for large gates, power operation is necessary and motor drives are commonly used. On many of the old water-power systems of New England the gates, and especially feeder canal head-gates of the sliding type, are often operated by water turbines directly geared to lineshafts which have shift gears on clutches to engage the individual gate hoists, of which there may be a considerable number, perhaps 20 or 30 on the large power canals.

Bear-trap gates of the Marshall, Lang, Parker and other types are operated directly by hydraulic means. These gates consist essentially of two or three leaves of steel or timber, hinged together in a series, working betwen parallel side walls. By admitting water under pressure due to the head on the dam to a chamber underneath the leaves, they rise in "A" shape and drop when the downstream outlet valves are opened, lying collapsed and flat on the bottom of the wasteway. Auxiliary protecting leaves cover the joints and keep out debris. Chains restrain the movement of the principal leaves. See Fig. 1 for line drawings of Lang and Parker types of bear-trap gates.

Automatic Gates

Various types of gates which can be balanced may be made automatic and control the level of the headpool within a few inches. Siphon Spillways may also readily be made automatic in operation. Shutters or flashboards pivoted horizontally at about one-third of their height will tip when the water rises over their top edge. Such gates do not give, however, an unobstructed passage for the water, and are liable to become clogged with debris. Rectangular leaf gates hinged at the base and sometimes called bear-trap gates are shown in Figs. 2 and 3. These are a good type of automatic gates, giving a free crest when open. The patents on this type are owned by Barrages Automatiques S. A., of Zurich, Switzerland. Three

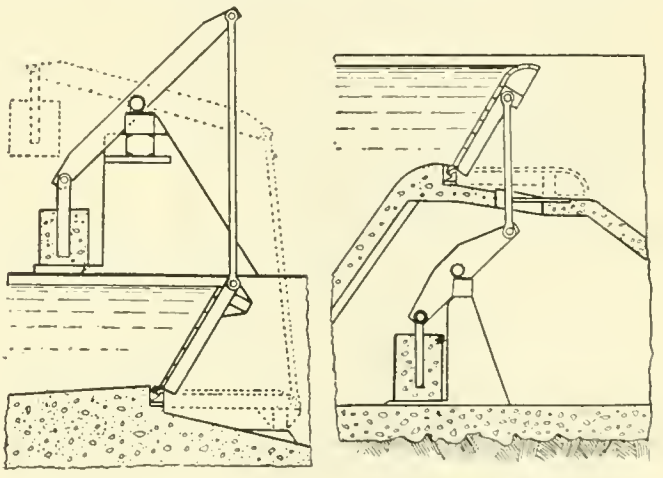


Fig. 2. Fig. 3.

FIGS 2 AND 3. RECTANGULAR LEAF GATES HINGED AT BASE. PATENTS OWNED BY BARRAGES AUTOMATIQUES S. A. OF ZURICH, SWITZERLAND.

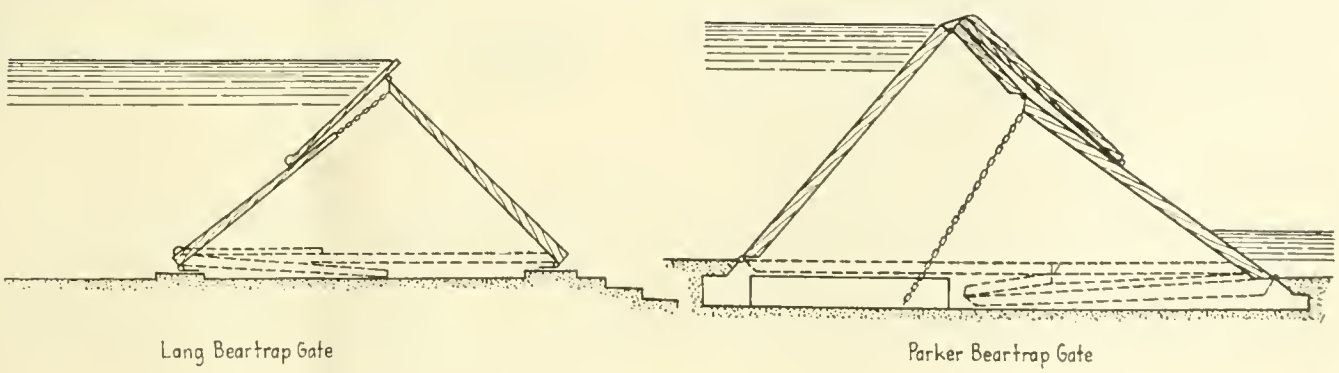


FIG. 1. ESSENTIAL FEATURES OF THE LANG AND PARKER BEARTRAP GATES.

installations of this sort have been made in the United States.

Cylinder Gates, Automatic and Otherwise

The Carstanjen rolling cylinder gate promoted by Maschinenfabrik Vereingte, Augsberg-Nurnberg, Germany, is also an interesting type adaptable to long crests. The principle of this is shown in Fig. 4. A similar gate has been patented by J. E. Jenkins, of New York, which operates directly by the pressure of the water, and is therefore automatic. The Carstanjen gates are operated by sprockets. There are now four installations of these rolling cylinder gates in the United States. One near Spokane, Wash., at the Long Lake plant of the Washington Water Power Company, designed by Machinenfabrik, has three of these cylinders, each closing an opening 65 ft. by 19 ft. Another gate of this type, 30 ft. by 8 ft., is

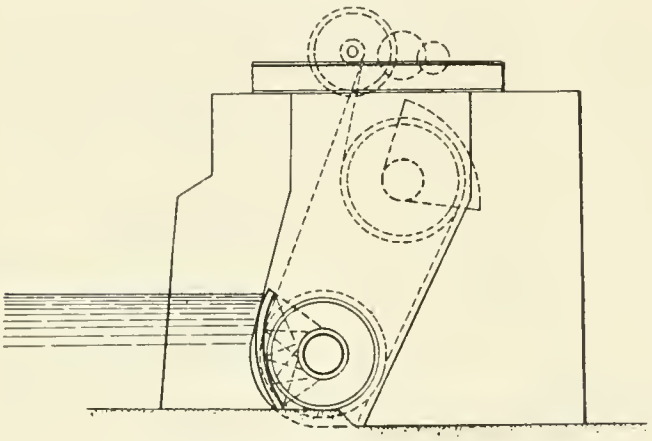


FIG. 4. THE CARSTANJEN ROLLING CYLINDER GATE ADAPTABLE TO LONG CRESTS.

in use near Boise, Idaho. The Grand Valley Reclamation Project, in Colorado, has six similar gates, 70 ft. x 10.25 ft., and one 60 ft. by 15.3 ft.

Tightening Devices

Gates which, like the slide gates, are held by the water pressure in contact with a frame, are water-tight so long as the contact surfaces are in good condition, with no foreign matter separating them. One of the surfaces in contact should be of bronze to reduce friction and prevent rusting tight.

Gates which are hinged are usually provided with flexible flaps of metal, leather, rubber or canvas belting over the joints. Tainter gates are also tightened at the side joints in this manner, usually by rubber fabric strips of 5 to 8 plies, and 6 to 10 ins. wide. These strips accommodate themselves to the curve of the gate, and under the pressure of water lie in a small radius curve against the gate piers. These piers at the arc of travel of the gates must therefore be smooth and true. The bottoms of Tainter and slide gates are frequently fitted with a timber sill. This has the advantage of being easily fitted to the masonry or steel sub-sill on the dam crest, but it has the serious disadvantage of being easily injured or torn off by ice and heavy debris passing with flood water.

A steel sill on the gate properly fitted to the concrete dam crest by forming the concrete against the gate sill itself is now thought to be a better detail. For the side tightening of Tainter gates a flexible bronze or thin steel plate is more permanent than belting and is standard practice in Europe.

Stoney gates, which are large slide gates carried on roller trains, are often tightened at the sides by a "staunching rod," see Fig. 5, which may be a piece of shafting 2 or 3 ins. in diameter, held in a "V"-shaped groove by the water pressure. One face of this "V" groove is fast to the gate and the other to the pier. The "staunching rod" is therefore only in contact along two vertical lines on the periphery of this piece of shafting. If the surfaces are true, this is a fairly satisfactory means of securing a water-tight joint. The shape of the groove with the contained cylinder forms a pocket for retention of silt and fine fibrous materials which are naturally drawn in by slight leaks past the cylinder, and this soon makes a tight joint. It would not be difficult to bend a piece of shafting to fit the side of a Tainter gate, but the machining of the "V" strips and securing them permanently in their correct positions is a more difficult matter.

If a Tainter gate side joint could be devised that would be more permanently tight and less subject to injury than the strips of belting now mostly used, this form of gate would be a very satisfactory gate for medium and large openings.

Hints to Operators

General Inspections—When gates are ordinarily submerged and can only be inspected when they are raised to pass flood, this opportunity should be taken advantage of to make inspection as to the condition of any parts of the gates which may then be readily reached. Steel Tainter gates should have their upstream surfaces carefully inspected for rust and more serious tuberculation, and if they are to remain open long enough to permit, a suitable

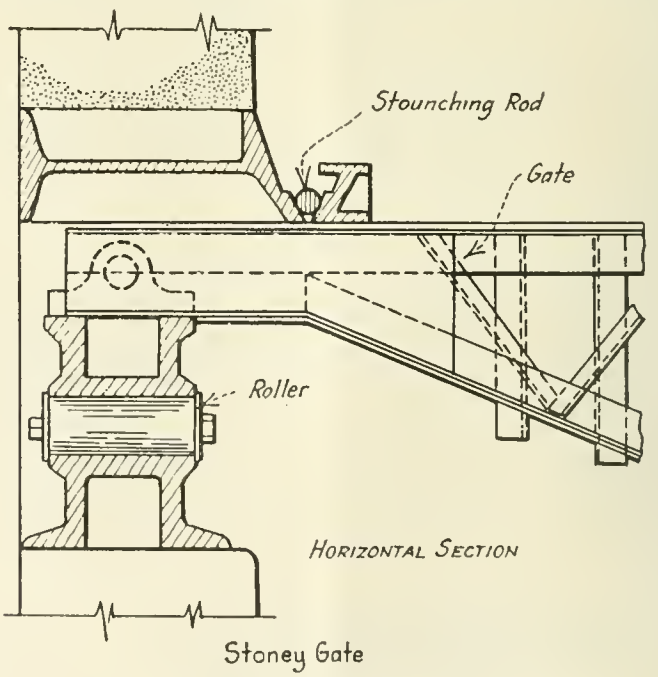


FIG. 5. STONEY GATE.

paint should be applied. Bituminous paints have, on the whole, been found to be the most satisfactory for painting surfaces of submerged gates or other steel which is in the water. It is necessary, however, to apply such paints to dry surfaces and preferably during warm weather.

Tightening strips should be inspected and replaced if needed, and the sills attached to gates also given attention. It is important that gates should be made as tight

as their design will permit, to avoid loss of water and consequent loss of power, and particularly to prevent accumulation of ice in the winter on the downstream side of the gate.

Winter Operation of Gates—Whenever floods are commonly expected during the winter months some of the gates should be kept thawed or in such condition that they can be opened within the time permitted by the usual rising time of the flood. Where there are not to exceed six or eight gates, the two end gates and possibly one central gate only will be kept thawed, as it is found within an hour or two after two end gates and possibly one central gate are opened, the movement of warmer water along the upstream faces of the other gates will also thaw these gates.

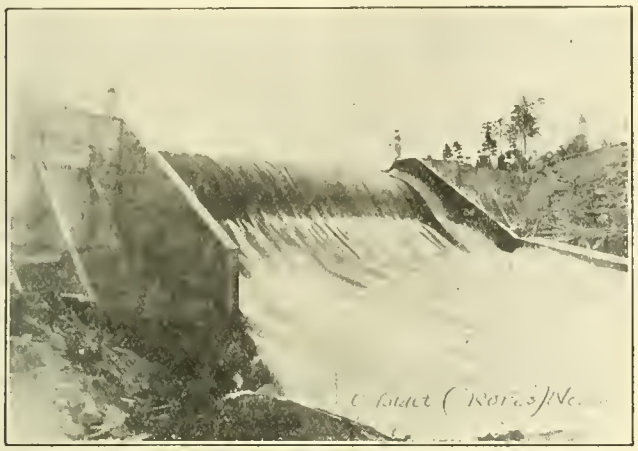


FIG. 6. UNDERHUNG COUNTERWEIGHT AUTOMATIC GATE AT OSFALDET (ROROS) NORWAY.

In chopping out gates in the winter, proper care must be exercised to avoid injury to the tightening strips. In thawing gates without steam-heating apparatus built into the gate face, care must be taken not to overheat any steel members on the downstream side of the gate, such as struts and arms of Tainter gates, by building open fires in close proximity to such member. Overheating these members might cause sudden buckling and collapse of the gate.

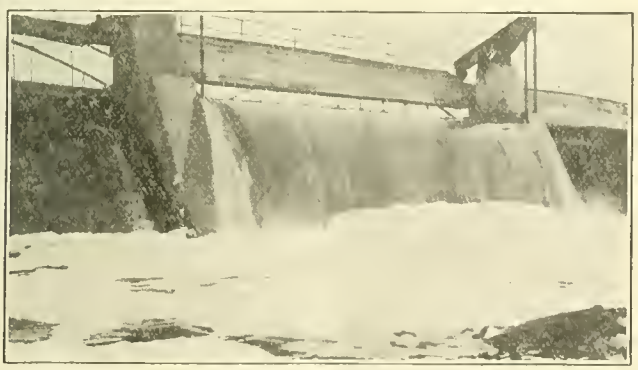


FIG. 7. OVERHEAD COUNTERWEIGHT AUTOMATIC GATE AT NASHUA, IOWA. SIZE 46 x 7 FEET. INSTALLED BY FARGO ENGINEERING CO.

Gate Hoisting Mechanisms—These should be periodically inspected by competent mechanics and all bearings put in alignment, cap bolts on bearings and elsewhere tightened, oil baths cleaned and replenished and worms inspected to know that there is no cutting. Ball bearings need careful inspection to insure that the ball races and other parts are in proper adjustment, lack of which will result in crushing of the hardened steel balls and consequent loss of the entire bearing by grinding caused by any such broken parts. Hoisting chains must be frequently inspected to see that no undue stretch has occurred which would both weaken the chain and perhaps unbalance the operation of the hoist if the gate is hung on more than one chain. Thus, if the chains are not of equal length the gate may jam at one end between the piers.

Steam-Heated Gates

It is now common practice to inclose a space on the downstream side of Tainter gates and to heat this space by means of steam coils within. Steam is fed to these coils by a swinging pipe centered in line with the gate pins. Low-pressure steam from the power-house heating system is entirely sufficient to keep the gate thawed out all winter. Such heated chambers may readily be supported by the gate arm and swing with the gate. The roof of the chamber should be made of steel plate so that any water spilling over the gate will cause no injury. Steam chambers have sometimes been inserted in the masonry piers and made to conform to the line of travel of the gate. In the case of Tainter gates such steel chambers would form the side bearing and smooth surface for travel of the tightening strips. In the case of mechanically operated bear-trap leaves, the side chambers, if used, would be inclined in the piers and would also form the bearing surface for the tightening when the gate is in its raised position.

It is to be expected in most climates that when the gate is spilling it will keep itself free. The best form of applying heat is by heated chambers, either fixed or moving with the gate, located on the downstream side or underneath the gate so as to keep warm the surface of the gate which is in contact with headwater.

Automatic hinge leaf gates of the underhung counterweight type are in successful operation at Osfaldet, Norway, within the Arctic circle, see Fig. 6. An overhead

FIG 8. "FIVE CHANNELS" HYDRO-ELECTRIC PLANT OF THE CONSUMERS' POWER COMPANY, AU SABLE RIVER IN MICHIGAN, SHOWING 24 x 13-FT. TAINTER GATES.

counterweight automatic gate, 46x7 ft., installed by the Fargo Engineering Co., at Nashua, Ia., is shown in Fig. 7. Tainter gates, 24x13 ft., in the dam of the Five Channels hydro-electric plant of the Consumers' Power Company, on the Au Sable river, in Michigan, are shown in Fig. 8.

NEW HIGHWAY TESTS BEING MADE BY THE BUREAU OF PUBLIC ROADS

By A. T. Goldbeck, Engineer of Tests, Bureau of Public Roads, Washington, D. C.

(Editor's Note:—The Bureau of Public Roads has been conducting a number of investigations on the effect of modern traffic on hard-surface roadways, and related problems, and in previous issues of this magazine the results of the tests made to determine the amount of impact delivered by motor trucks on roads have been recorded in brief form. The present article, extracted from the paper by Mr. Goldbeck, as presented at the recent annual meeting of the American Road Builders' Association, refers to the other major investigations the Bureau is making.)

A Study of the Effect of Impact on Different Types of Road Surfaces

A knowledge of the force delivered to a road surface by traffic of itself is not of very great value unless we can couple this information with the effect of that force on different types of surfaces. We are therefore conducting a series of tests with this idea in view, namely, determining the effect of impact on different kinds of road surfaces. For carrying on this investigation we have constructed a number of slabs 7 ft. square and laid directly on the subgrade. These specimens include concrete slabs of 1:1½:3 mix, 2, 4, 6, 8 and 10 ins. in thickness, and several slabs 14 ft. square, 6 ins. in thickness. We have a number of different types of brick slabs built with wire-cut lug, repressed and also vertical fiber brick. Some of these are laid with sand-cushion construction, some with monolithic and some with semi-monolithic construction. We have used sand cushion and also bituminous mastic cushion. We have likewise used several different types of filler, including cement grout, bituminous filler and bituminous mastic filler. The concrete base is 4 ins. under some of the slabs and 6 ins. under some of the others. We have likewise constructed slabs with 3-in. wire-cut lug brick, monolithic construction with 3-in. and 4-in. concrete bases. We have also constructed a few slabs laid on 6 ins. and 12 ins. of macadam. We aim to continue these tests, using a large number of different types of construction that may look promising.

Impact Machine

The above slabs will be subjected to impact by means of a special machine constructed for that purpose. It is designed to give impact conditions similar to those given by the rear wheel of a heavy truck. In its present form the machine consists of a 2,000-lb. weight, shod at the bottom with a 12-in. solid rubber tire and carrying a 6,000-lb. weight supported through the use of a single heavy truck spring. The entire weight of 8,000 lbs. may be raised by means of a cam gear-driven by gasoline engine, so that repeated impacts may be delivered at one spot on the slab until failure takes place. We have instruments mounted on the machine which autographically show us the deceleration or suddenness with which the weight is brought to rest upon the slab. From these curves it is possible for us to measure the exact force of the impact. We likewise have instruments to enable us to measure very carefully the deformation of the slab under the repeated blows of this machine.

As the condition of the subgrade will undoubtedly affect the load-supporting value of the surfacing, we have constructed duplicate sets of specimens, one set of which is laid on a subgrade which will be purposely kept in a moist condition and therefore be of low bearing value, and the other is laid on a subgrade which we will endeavor to keep dry and thus obtain a high bearing value. From the results of these tests we should be able to say just what types of roads may be considered as comparable so far as their resistance to pounding of heavy trucks is concerned.

A Study of the Effect of Traffic on Different Types of Road Surfaces

We are conducting still a third series of tests which were designed primarily to enable us to develop suitable laboratory tests for stone paving block, but which we are using incidentally to give us some idea of the relative wearing qualities of different types of surfacings when they are all subjected to exactly the same traffic.

We have constructed a straight-way track, 400 ft. in length and 2 ft. in width, in which are laid 49 different sections of pavements. As at present constructed, these sections include concrete having different kinds of coarse aggregates, including trap rock, gneiss, gravel, soft sandstone, limestone and air-cooled blast furnace slag. There are a number of different kinds of brick pavements in which brick having different perentages of wear are used, the percentages being 16, 19 and 24 per cent. in the rattler test. There are likewise sections in which 3-in. brick are used. Both sand cushion and semi-monolithic construction have been employed. The type of filler has also been varied to include cement grout and bituminous fillers. There are also a number of stone block sections constructed of block from different parts of the country. The filler has likewise been made to include bituminous as well as Portland cement fillers.

Over these sections a wear machine is hauled by means of a cableway. This machine consists essentially of five large cast iron wheels, each weighing 1,000 lbs., with a tire width of 2 ins. Each of these wheels is perfectly free and independent from the remaining wheels, and its full weight is exerted on the road surface. They are so arranged that they travel over a strip 12 ins. in width, and there is considerable impact action exerted by the heavy unsprung weight of these wheels, and the action of this device is rather one of heavy impact than abrasion. Although the machine has made less than 2,000 trips at the present writing, several of the weaker types of pavements have shown signs of failure.

A Study of the Bearing Power of Subgrades as Affected by Moisture

It is common knowledge that whereas city pavements may stand exceedingly heavy traffic, those same pavements, when laid on country highways, develop weak spots and defects which require considerable maintenance. The difference between the city pavement and the country highway very obviously is that of drainage. The subgrade under city streets is generally in very much better condition than that of country highways, because it is possible to keep the subgrade under city streets very much drier than the subgrade under country highways.

The bearing value of most soils is very greatly decreased by the presence of water, and one of our greatest

problems in road construction today is to develop means for keeping water out of the subgrade. It would seem that our present-day methods of drainage of roads do not always accomplish the purpose for which they were designed, and tests are being undertaken to discover means for enabling us to develop the bearing value of subgrades to the maximum possible extent. The experiments in this direction include experiments to determine the bearing value of soils containing different percentages of moisture, studies of capillarity in soils, and will include studies by means of models and full-sized road sections, to determine the best means for excluding water from the subgrade.

We are making an earnest effort to place road building on a much more scientific basis than exists at the present time. We should like to be able to gain enough knowledge so that having a given set of conditions of climate, subgrade and traffic, we shall be able to say with considerable certainty what constitutes the best type of road for those conditions. It would be very desirable if we were able to obtain information enabling us to say definitely that one type of road was comparable with another for carrying the same traffic. We believe that knowledge of this kind can only be had through tests of the character described in conjunction with a study of the behavior of roads under service conditions.

EFFICIENT DETOURS FOR HIGHWAY CONSTRUCTION

By L. H. Neilsen, Deputy State Highway Commissioner, Lansing, Mich.

In providing for the maintenance of the Michigan trunk line system it seems to have been the intention of the Legislature of 1919 to insure that the different routes in the state trunk line highway system should be maintained in the best possible condition, said Mr. Neilsen in an address at the recent Short Course of the University of Michigan. Although it was manifestly out of the question to arrange for the substantial improvement of the different portions of the system immediately, it has been found feasible to improve their condition very materially by making the best possible use of the local materials at hand. The public foots the bill and is certainly entitled to every effort on the part of those connected with road work to insure as comfortable and expeditious travel over every section of the trunk line highways as conditions will permit.

Suitable Detours

In the past I fear that all of us have been more or less negligent in taking pains to provide for traffic over and around sections which were unimproved. The Legislature of 1917 recognized this fact when it placed on the statute books Act No. 165. This law provides that the highway officials having jurisdiction shall have authority to close to public travel any road or bridge under construction, on condition that suitable barriers are erected at each end of the closed portions, and that suitable detours are provided. Notices must be posted showing the route to be followed and measures must be taken to place and keep these detours in reasonably safe and passable condition for travel. When the improvement under way shall have been completed and the section again opened to traffic, it further provides that these barriers and all signs and notices directing traffic to the detours shall be removed.

Michigan Practice

Many contracts have provided that where traffic could not be carried over the road during the progress of the work the contractor should bear the expense of providing and maintaining the detour. This practice has been discontinued as far as the work handled by the State is concerned. The maintenance of the detours is being taken care of as a part of the regular State trunk line maintenance program in each county. The results secured have fully justified this change in policy. In some instances detours are being maintained because the trunk line route as laid out is not as well improved as a road a short distance away, and in some cases the route is not opened and cut out as a public highway. Just as soon as sufficient work has been done on the trunk line route itself to make it a more economical road to maintain, the maintenance organization of the county is being asked to take care of the route actually laid out in place of the detours which were temporarily authorized. During the coming season it is planned to have resident engineers in charge of construction make weekly reports on detours, commenting on their condition. These reports will go to the district engineer and to the main office, and when necessary the county maintenance organization will be requested to make improvement in the condition of the detours.

Plates are being prepared for a map of the State which will show the trunk line routes and their numbers. The stencils and instructions for their use, together with the maps showing the location of the trunk line routes and their numbers in each county will be sent out soon, and it is hoped to have the work of marking the system completed by the middle of May. The Highway Weather Bulletin, published twice a week by the East Lansing office of the U. S. Weather Bureau, has been a very great service to the traveling public during the past winter. It is proposed to continue this service through the summer, publishing, however, only one bulletin each week. It is planned to use this bulletin to show what sections of the different routes are under construction, and also to indicate the conditions of the detours and unimproved portions of the trunk lines, since these are the ones which will be first affected by rains.

Wherever arrangements are made to carry work through on roads which are unimproved it certainly must be expected that the contractor will render every service to the traveling public without allowing any of his employes to make a charge for helping the people through.

MOTOR TRUCKS AND OUR PAVEMENTS

By Monroe L. Patzig, Consulting Engineer, 418 Kraft Bldg., Des Moines, Ia.

Five years ago there were but few heavy trucks in general use for commercial purposes. Today there are more than 953,000 in the United States.

Paved streets no doubt have had a great deal to do with the fast growing demand for commercial cars, but the effect that this growth has had upon our pavements has been a serious one to those in charge of road and street

construction. Bituminous pavement construction that was perfectly satisfactory five years ago, may today be entirely unfit for present traffic.

Where traffic has been concentrated so as to follow single lines of travel, paths have become worn in concrete, brick, bitulithic and wood block pavements. Asphaltic concrete, sheet asphalt and bitulithic have shown tendencies to push or roll.

These conditions are not only true in Des Moines but evidences of the same conditions exist in all our large cities. In some of these towns where traffic has for a great many years been congested with heavy teaming over the hard surfaces of concrete, brick, stone, wood block and bitulithic pavements, the tendency to form ruts or ridges has been apparent. But with the increased use of heavy motor cars these same tendencies to rut the hard pavements and to cause rolling or shoving of the soft pavements, have been carried on to many streets that have never before shown such defects.

Conditions in Des Moines

That this is not caused merely by the general growth of the cities and the shifting of traffic to certain streets can be demonstrated by some streets in Des Moines and a thoughtful analysis of what takes place on the pavement when horse drawn or motor drawn vehicles pass over it.

As examples of brick paving may be named Beaver Ave. and South 9th Street laid in 1910. These were narrow pavements upon which hauling was confined generally to a single line of traffic. On south east Sixth Street, East 14th Street, and West Grand Ave. can be seen results of traffic on concrete pavements. Ingersoll Ave., Mulberry St., 10th St., Clark St., University Ave., and Third Street show results of modern traffic on Bitulithic Pavement. All of the foregoing represent the effects on hard surfaces and in these cases the pavements show a disintegration caused by the pounding effect of the traffic.

On West Court Ave., Mulberry St., West Grand Ave., and West Ninth Street will be seen examples of sheet asphalt pavements that have pushed or rolled under tractive force of motor vehicles. It is on this type of pavement that our first attentions were forcefully drawn. At no time before the heavy motor truck age were these difficulties experienced. The writer's attention was first called to the effects shown upon West Court Avenue between First Street and Fifth Street.

This pavement was carefully constructed under the most rigid inspection known to Des Moines. It was considered an ideal piece of work when completed; within 2 years there had developed many exasperating waves and depressions and repairs were necessarily made. Upon making these repairs it was determined that the paving material had bunched up and actually moved along over the base. The movement, therefore, had actually polished the concrete foundation.

While the causes for this may partly be due to the construction which was specified for this piece of work, we are also aware of the fact that the changed traffic had much to do with it.

At the same time the public was irritated by the conditions on this street, similar defects appeared on Mulberry St. between 7th and 9th Streets, although this pavement was then about 5 years old and had been in perfect shape until that time. Other streets showed movement of the wearing surface to a marked degree at about the same time, but all of them along routes taken by the heaviest motor drawn vehicles. A careful consideration of this matter has also revealed the same circumstances and results in practically all of the larger cities.

Impact

Now the cause seems very simple and clear. Where our heaviest loads rarely exceeded 3 or 4 tons, at the present time our pavements carry loads up to 12 and 15 tons. The load is considerably increased but the action upon the pavement is a great many times more severe due to the rebounding action of the springs, which causes an impact or hammerlike blow on the pavement. The springs cause a succession of these blows upon hitting a depression or other obstacle in the roadway. The speed of the car also intensifies these blows, for it has been demonstrated by authorities on this subject that the impact is greater with increased speeds.

For the sake of showing this more clearly let us assume two large balls of equal size, one weighing one ton and the other weighing 4 tons. The small one will represent the weight upon one wheel of a heavily laden coal wagon while the other will represent the load on one wheel of a 16-ton truck loaded to its capacity. Imagine these two balls rolling over a smooth surface until we come to a depression. Here you will notice the balls to drop down into the depression if deep enough and thereby give a hammer-like blow on the bottom. If the depression is slight the impact will be thrust upon the opposite side with a tendency to enlarge the size of it. In the case of both balls traveling at the same speed you will readily see that the impact of the larger is about four times that of the smaller. If the larger ball travels faster than the small one the difference in impact will be still greater. Now if the ball exerts its pressure on the surface through the action of springs, I believe you can see how this impact will set up a series of these blows which are directed along the line of travel. Now if you will think of this surface which we have been running over, as made of some soft material as asphalt or some other yielding material, you can readily understand how these impacts have a tendency to make depressions or to increase them in size. This is exactly what takes place on our asphalt pavements and as described has occurred on certain streets.

This is a very serious matter and it has made an investigation necessary to determine the cause before a reasonable remedy could be prescribed.

By again considering the soft surface, one can readily see how the surface will resist these impacts if made of tougher and harder materials. I say tougher because one may make the surface so hard that it becomes brittle and will not resist the impact. Upon making it harder and tougher it will not be dented so easily.

In a pavement too soft to resist the strain, I believe one can also see what happens when brakes are suddenly applied or the turning power is suddenly applied to the wheels. The tendency is to push the surface either forward or back. By examining surfaces at certain street intersections one will see that this has actually occurred.

Constructing Bituminous Pavements for Truck Traffic

It is a fact that bituminous pavements, and especially those using the smaller sizes of mineral aggregates, are ideal for paving purposes for the reason that they can be made hard and tough or brittle.

Since the cause has now been determined, it is a comparatively simple matter to construct bituminous pavements so as to resist the traffic we now have. Many streets have since been laid in Des Moines in accordance with this theory and are proving entirely successful, whereas if they had been laid in the same manner ten years ago the practice would have been condemned.

To those who are not familiar with the construction and proportions of bituminous pavements the writer hopes to drive away the fear that may have existed upon seeing the bad effects during the past five years. Where competent supervision of such construction exists, no better type of pavement can be had. The entire situation is now well under control, and better results can be secured with bituminous pavements than with many other materials.

The entire situation is one that could not have been forseen. Trucks are being used more and more each day and more disastrous results can be looked for on brittle road surfaces. As to bituminous surface construction under the supervision of competent persons, good results will be obtained.

Preventive Measures

Where it was formerly desirable to use as the proper consistency for asphaltic cements 65 to 75 penetration or higher, in order to prevent cracking of the surface, penetrations of 50 to 65 are now found successful to combat the heavy truck traffic of today.

It is also necessary to guard more closely the grading of the mineral aggregate so as to prevent the use of mixtures that will be likely to creep. A mixture containing too large a percentage of dust or fine material will be likely to shove or creep, and likewise too high a per cent. of larger aggregate will not have sufficient stability to resist the tendency to push it out of place.

It has also been found necessary to use a mixture similar to the wearing surface of a sheet asphalt pavement to cover the coarser asphaltic concrete or bitulithic pavements. Without this covering winter traffic has shown itself to be severe on this type of construction, and the mixture breaks up or disintegrates very rapidly. To prevent this unraveling from continuing it is necessary to cover this surface with another seal coat or mixture as just described. As long as the coarse aggregate is exposed to the weather and traffic it is certain to occur again if the traffic conditions are not greatly decreased.

THE IMPORTANCE OF ZONING A MUNICIPALITY

By Louis Bartlett, Mayor of Berkeley, Cal.

We are all familiar with residence parks, where the restrictions on the improvements are included in the deeds to the property. They have been tremendous successes. And today tens of millions of dollars in assessed valuations owe their existence to them. The zoning of cities brings about throughout the city the advantages gained in these residential parks, and it brings to the poor and people in moderate circumstances the advantages which have heretofore been reserved almost exclusively for the rich. It is essentially democratic, for it prevents the hog from imposing upon his more timid or poorer neighbor, who cannot afford to protect himself by an additional investment, said Mayor Bartlett in addressing the 21st annual convention of the League of California Municipalities.

Right to Establish Zones

Zone laws are passed by virtue of the police power of the State. It is that power which allows a State to interfere with private rights in the public interest for the protection of the morals, health and safety, and even for the convenience of the public. The legal status of zoning has not been defined as yet by the courts, but some very interesting cases from the highest courts of the land are the forerunners of others which, in my judgment, will ultimately establish everywhere the right of cities and of the State to establish zones. The restrictions thus far made divide cities into zones according to the height of the buildings and the area to be covered by each, and the use to which the property may be put.

Height Limits

It was determined rather early that height limits were within the police power. For example, in Boston it was decided that the municipal authorities could divide the city into different districts, each of which should obtain a different height limit. The court held that this was a reasonable measure of protection for the public health and safety, and alluded particularly to fire protection and to the health of dwellers in tall apartments and residences.

In California we have a State Tenement House Law based upon the Housing Code adopted in Berkeley some years ago, prepared under the general supervision of Mr. Frank V. Cornish, our city attorney. This Housing Code provides height limits, and what portion of the area of the lot may be covered by buildings. The restrictions of the use to which land may be put has not been so thoroughly tested in the courts as the height and area limitations have been.

Los Angeles the Pioneer

Los Angeles was, I think, the first city in the country to experiment with a zone law of this character. It was passed in 1909, and provided for certain business districts defined in the ordinance, and left the rest of the city for residences. The act was passed after an intensive study of the existing conditions in the city, and in the light of later laws is rather crude. Nevertheless it was a distinct step forward and has been of great value to the country at large, because it has gone through the courts of California and the United States Supreme Court, and we have learned some things which a zone law can do without violating the state and national constitutions. For example, it prohibited laundries except in designated places, and went so far as to abate a brick kiln which had been in existence for many years, even before the location was annexed to the city of Los Angeles. The Supreme Court of the United States went so far as to say that the character of the neighborhood of the brick kiln having changed into residential one, it was within the police power of the city to suppress it by a zone law in the public interest, as it interfered with the social use to which the surrounding property was being put.

Tendency of Zone Laws

The tendency of later zone laws has been to make more minute classifications than the early Los Angeles ordinance. At the present time there is pending before the city council of Berkeley a zone law which divides the

city into three main classifications—residence, business and industry. Industry is subdivided into the noxious, such as soap works, oil works, incinerators, abbatoirs, etc., that are put off by themselves. And then other factories. Business is similarly divided into the high-class retail district that suffers from the close proximity of garages, etc.; and then the wider business district that includes garages and similar institutions. All classes of residences, whether they be apartments or flats, boarding houses and hotels, are permitted in the residence district. And there is another classification for public and semi-public buildings, such as schools, churches, hospitals, etc.

The ordinance legalizes the existing use of every piece of property so as to avoid hardships, and it permits residences in the other ones, though it does not permit other uses in the strictly residential ones. As you see, this ordinance is not a very rigid one. Far less rigid than would be imposed if a new city were to be laid out. Too many vested interests are at stake, and too violent a change would be not only difficult to accomplish, but might work injury to a considerable number of people. The purpose of the zone ordinance is to prevent that very thing, and wherever established it does do that if wisely drafted. We have now the experience of a good many years in residence districts, and can say with finality that they are not only beautiful and attractive, but sound from an economical sense. Property values are maintained and the assessment roll gradually rises as the residence districts become more built up and attractive. The great loss that comes from the indiscriminate use of property for various purposes was easily visualized when one block in New York lost about seven million dollars of assessed valuation because of a change in use.

Berkeley Zone Law

We have a zone law on the Berkeley statutes at the present time which differs in operation from the one of which I have spoken. It consists of a series of definitions of zones. One permits single family residences only. Another flats and single family residences. Third, flats, multiple houses and single family residences. Fourth, apartment houses, boarding houses, fraternity houses, etc., without stores underneath. There are a number of different classifications, but these are illustrative. If the residents of a part of town wish to put themselves into one of these classes they petition the council, and then the neighbors are notified, and after hearing the area may be classified by the council into one of these zones. At the present time about five per cent. of the city of Berkeley is so classified—largely into the single family residence zones. This zone corresponds roughly to the restrictions in private residence parks, although it is not nearly as stringent, as it does not involve set-back lines, prohibition against the ownership by negroes and Orientals, etc. So far as I know the legality of this particular kind of zone has never been up before the courts, but in my judgment the courts will sustain it, for the only question involved is, Is this a reasonable exercise of the police power of the State? Does it, in other words, promote the public health, welfare, safety or convenience? Inasmuch as tens of thousands of people have answered that question for themselves in the affirmative by buying into restricted districts, and millions of dollars of property values have been built up in this way, I think it extremely unlikely that the courts will hold this an unreasonable exercise of the police power.

Education Necessary

There is a very practical problem in the zoning of municipalities, and that is the problem of educating people so that they can understand its advantages. The first thing to do is to prepare a use map of the city, showing the use to which every piece of property is put. Then neighborhood meetings should be called and those in the neighborhood asked what restrictions, if any, they want for their property. When this has been done throughout the city there is a fair chance that the law may be adopted without great opposition. And it is to be noted that the law that will be first adopted will not be perfect. It will develop injustices and inequalities which may be brought sharply to the attention of the city authorities. But if the law has been prepared with care there will be far fewer of these than if the city be not zoned at all. For without zoning it is in the power of any private individual to create an unjust situation on all sides of his property, and many owners are doing that every day. It must be borne in mind, too, that cities grow, and that we should not regard a zone law as something which cannot be amended. We should be prepared to expect growth and to guide it wisely in the changing of the lines in the zones.

COMPUTATION OF BACKWATER CURVES IN SEWER DESIGN

By C. D. Hill, Engineer, Board of Local Improvements, City Hall, Chicago, Ill.

In designing large sewers with free discharge, and where it may be reasonably expected that the surface of the water near the mouth o the sewer at flood will be approximately at mid-depth of the sewer, it is of great importance to be able to determine the rise of the surface of the water upstream, commonly called the backwater curve. Under these conditions the outfall section of the sewer has much greater capacity than the same sized sewer at a greater distance from the outfall. It is possible to economize on the size of the sewer, and particularly where the ground is low near the outfall it is possible to diminish the vertical diameter, thereby obtaining more cover over the sewer without in any way affecting the capacity of the sewer.

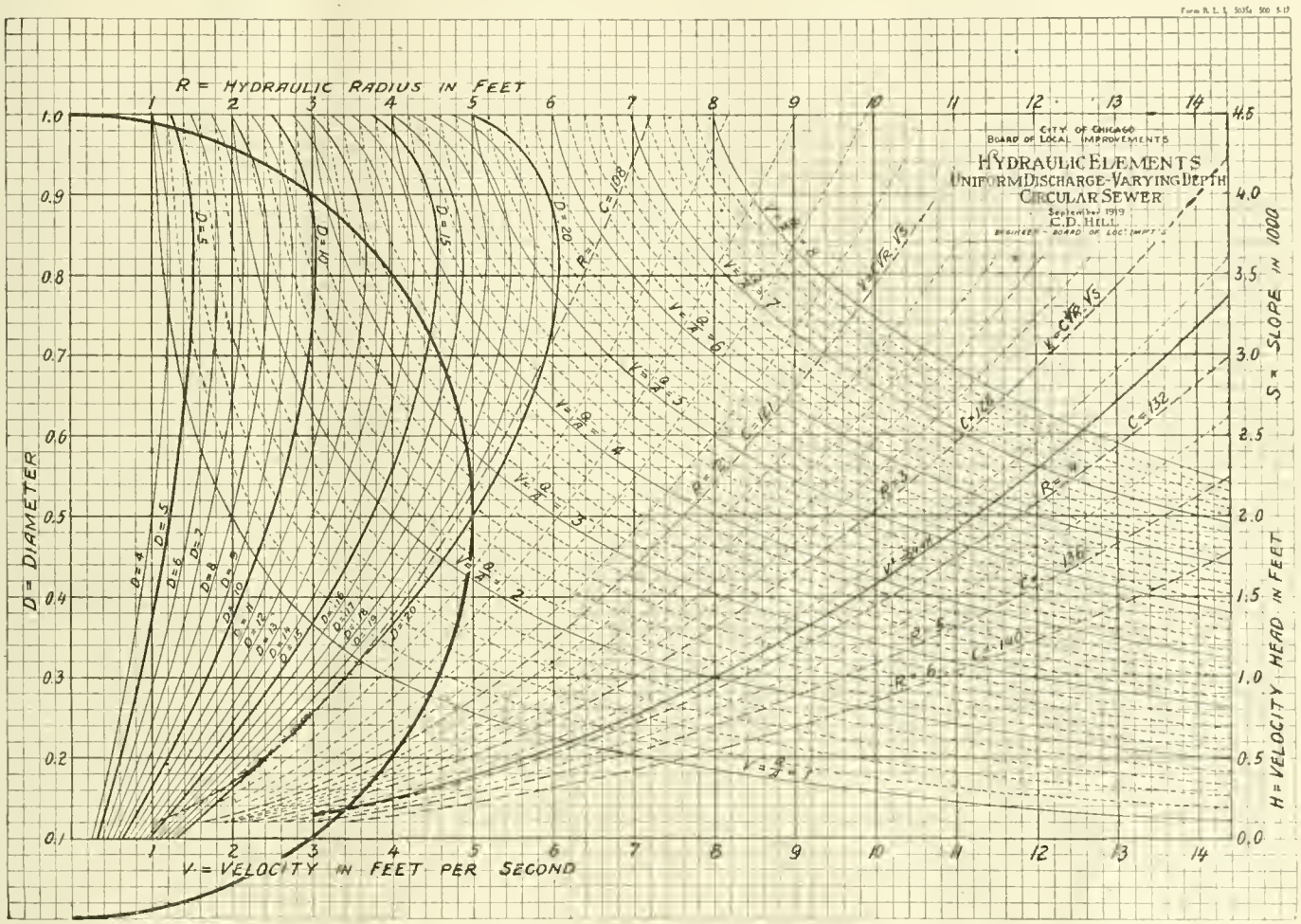
Uses of Backwater Curve

The backwater curve is useful in the design of sewers exceeding 6 ft. in diameter when, on account of the low elevation of the land to be drained, it is necessary to build the sewer at a minimum gradient. The velocity of flow in a sewer is determined by the slope of the surface of the water and not by the slope of the bottom of the sewer. Under certain conditions it can be shown by the backwater curve that an adequate velocity will be maintained, while too low a velocity would be indicated by the slope of the sewer. With sewers less than 6 ft. in diameter the use of the backwater curve is of little value, for the reason that the rise of the water is so rapid and the distance from the outfall to the full section is too short.

Another important use of the backwater curve is to obtain the approximate water level at various localities in

the sewer district at times of flood, when an assumed run-off occurs, and to judge of the effect of the backwater on basements of buildings.

In one design it was proposed to carry 275 second-feet through a 10 ft. relief sewer with a gradient of 0.03 per hundred. The sewer was to have a free discharge into the river and was to be over a mile in length. On the assumption that the 10 ft. sewer would flow full at the upper end, it was found that basements drained by a lateral sewer would be flooded. However, computations



CURVES SHOWING HYDRAULIC ELEMENTS FOR CIRCULAR SEWER FOR UNIFORM DISCHARGE AND VARYING DEPTHS.

showed that under the conditions the depth of water at the upper end would be less than 7 ft. and that the basements would be drained.

Such computations have been made by engineers, but the writer is not aware of any published description of the method employed, although the principles involved are discussed and the method indicated in Merriman's "Treatise on Hydraulics."

Assumptions and Computations

The usual method involves a great many tedious calculations. The assumption is made that a constant volume of water is flowing through the sewer, that the depth of water near the outfall is a definite amount determined by local conditions, that at an unknown distance from this point the depth of water is a definite amount slightly greater, the problem being to compute the distance. It is necessary to compute the wetted area at successive cross-sections of the sewer corresponding to assumed depths of water, to compute the hydraulic radius, the velocity, the velocity head and the corresponding slope at such cross-sections at each of which a definite depth is assumed, and from these elements to compute the distances between the successive cross-sections.

The distance between two cross-sections multiplied by the slope of the sewer, plus the difference between the depths of water at the two cross-sections, equals the difference between the elevations of the surface of the water at the two cross-sections. This difference must equal the head necessary to overcome the frictional losses due to the average velocity between the stations; that is, the distance between the cross-sections multiplied by the hydraulic slope corresponding to the velocity and the hydraulic radius, plus the difference between the velocity heads of the two cross-sections. This may be expressed:

$$L S_1 + (d_2 - d_1) = L S + (H_1 - H_2)$$

$$L = \frac{(d_2 - d_1) - (H_1 - H_2)}{S - S_1} = \frac{d' - H'}{S'}$$

The elevation of the bottom of the sewer being known and the elevation of the surface of the water at the first cross-section being assumed, the elevation of the surface of the water and the location of the successive cross-sections can be computed.

The computations are based on the fundamental as-

sumption that the volume of flow is constant and that there is no substantial contribution to the flow between cross-sections. At points where the volume is increased by contributions from lateral sewers it is necessary to make allowance for loss of head due to change of velocity. At curves and at changes of diameter loss of head should be estimated.

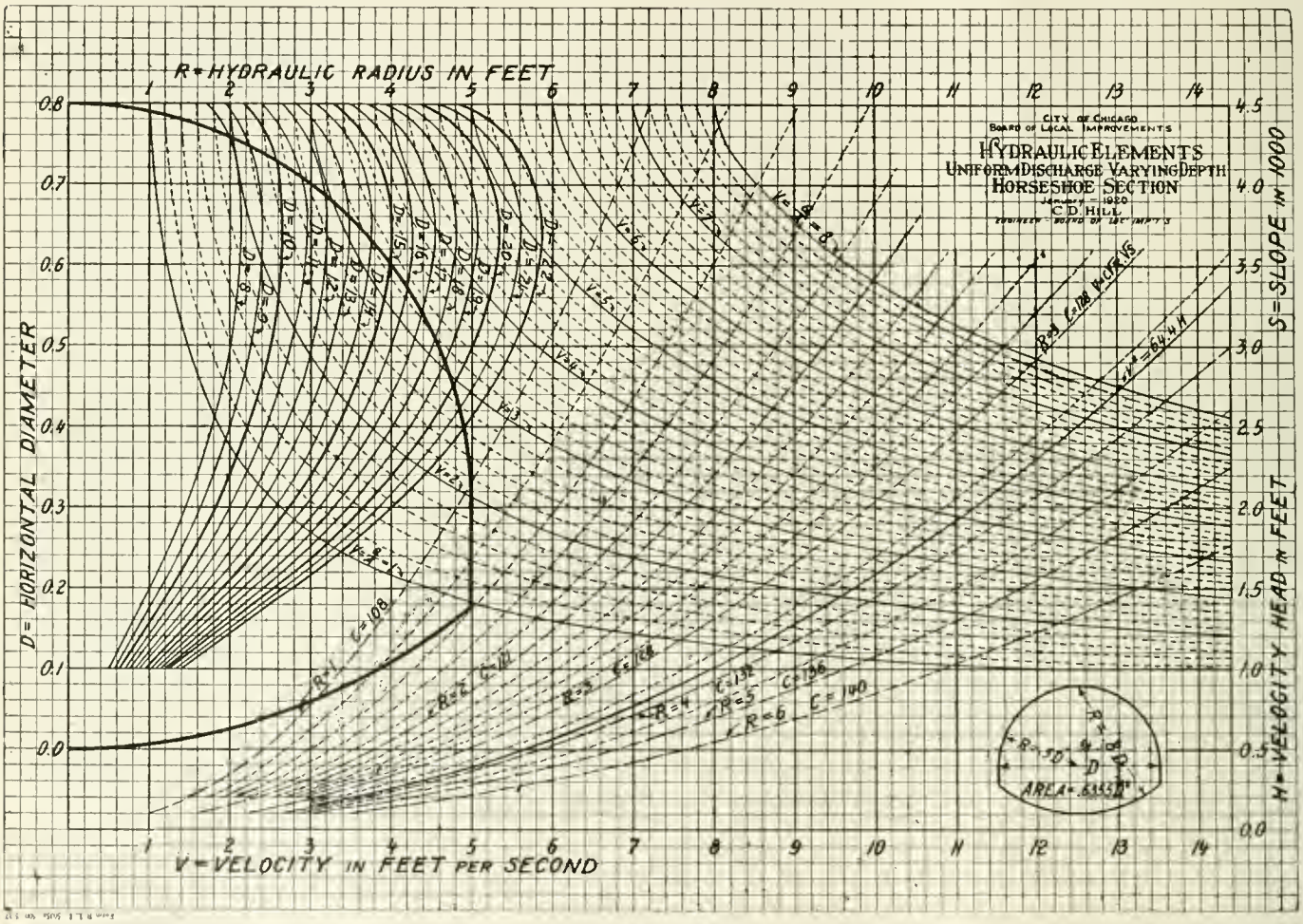
Computation Sheet

A great deal of the tediousness of the computations can be avoided by the use of the computation sheets and the diagram which is published herewith.

At the top of the computation sheet should be recorded the diameter of the sewer in feet, the assumed volume of flow, the area of the full cross-section of the sewer, the velocity of the assumed volume flowing through the full bore of the sewer, and the gradient or slope of the sewer. In the first column enter the assumed depth in decimal parts of the diameter for each cross-section; in the second column enter the same depth in feet; in the third column enter the difference in feet between the depths at successive cross-sections; in the fourth column enter the hydraulic radius corresponding to the depth at each cross-section; in the eighth column enter the velocity, equal to the volume divided by the wetted area, for each cross-section; in the fifth column enter the corresponding velocity head; in the sixth column enter the difference between the velocity heads at successive cross-sections; in the seventh column enter the difference between the quantities in the third and in the sixth columns; in the ninth column enter the hydraulic slope corresponding to the velocity and the hydraulic radius of each cross-section; in the tenth column enter the difference between the hydraulic slope and the slope or gradient of the sewer; in the eleventh column enter the computed distance between successive cross-sections; in the twelfth column enter the elevation of the bottom of the sewer at each cross-section, and in the thirteenth column enter the corresponding elevation of the surface of the water.

Using the Diagrams.

By means of the diagram it is possible to read directly the hydraulic radius, the velocity, the velocity head and the corresponding slope for any cross-section of a sewer through which an assumed volume of water is flowing at an assumed depth.


R = HYDRAULIC RADIUS IN FEET
D = HORIZONTAL DIAMETER
V = VELOCITY IN FEET PER SECOND
S = SLOPE IN 1000
H = VELOCITY HEAD IN FEET
CITY OF CHICAGO
BOARD OF LOCAL IMPROVEMENTS
HYDRAULIC ELEMENTS
UNIFORM DISCHARGE VARYING DEPTH
HORSESHOE SECTION
JANUARY 1920
C. D. HILL
ENGINEER - BOARD OF LOC. IMPTS.
AREA = .8345 R²

CURVES SHOWING HYDRAULIC ELEMENTS FOR HORSESHOE SEWER FOR UNIFORM DISCHARGE AND VARYING DEPTH.

On the scale at the left margin of the diagram is read the assumed depth of water expressed in decimal parts of the diameter. On the scale at the top of the diagram is read the hydraulic radius of sewers of various diameters at any assumed depth of water which is indicated by the intersection of the horizontal line corresponding to the diameter.

The curves $V = \frac{Q}{A} = 2$, etc., show the velocities, read

at the bottom of the diagram, of a constant volume flowing at various depths corresponding to the velocity of the same volume flowing through the full bore of the sewer.

The intersection of the curve $V^2 = 64.4\ H$ with the velocity ordinate shows at the right margin of the diagram the velocity head corresponding to the velocity.

The curves R=2, C=121, $V = C\sqrt{R}\sqrt{S}$, etc., show the relationship between the velocity, hydraulic radius and slope; the first two being indicated by the velocity ordinate and the curve, the corresponding slope can be read at the right margin of the diagram. The value of C corresponding to each value of R is obtained by Kutter's formula with a value of n = .014.

It is believed that the errors due to the inaccuracies of the diagram are much less than the errors due to the assumptions in regard to the water flowing through sewers.

To use the diagram, enter at the left margin of the diagram at the elevation corresponding to the assumed depth of water at the cross-section under consideration.

Note, and record on the computation sheet, the assumed depth in feet and in decimal parts of the diameter. Trace horizontally to the right to the intersection with the curve

Backwater Curve Computation Sheet
Uniform Discharge - Varying Depth

D=			Q=		A=		V=$\frac{Q}{A}$=				S_1=		L=$\frac{d_1-H_1}{S_1}$
1	2	3	4	5	6	7	8	9	10	11	12	13	
Depth			R	H	H_1	d_1-H_1	V	S	S_1	L	Elevation		
D	d	d_1									Sewer	W.L	

corresponding to the diameter of the sewer, and read at the top of the diagram, and record the hydraulic radius. Continue to the right to the intersection with a curve corresponding to the velocity when the sewer is full, trace vertically downwards and at the bottom of the diagram, read and record the velocity. Where the velocity ordinate intersects the curve $V^2 = 64.4\ H$ trace horizontally to the right margin of the diagram, read and record the corresponding velocity head. Where the velocity ordinate intersects the curve corresponding to the hydraulic radius, trace horizontally to the right of the diagram, read and record the corresponding slope.

Repeat these operations for the successive cross-sections. Compute d', the difference between the depths at two adjacent cross-sections. Compute H', the difference between the velocity heads at the same cross-sections. Compute S', the difference between the slope S, as read on the diagram and S_1, the slope of the sewer. Compute L, the distance between the cross-sections by dividing d' — H' by S'.

DESIGNING STREET PAVEMENTS FOR SMALL MINNESOTA CITIES

By George M. Shepard, Associate with Louis P. Wolff, Consulting Engineer, St. Paul, Minn.

As a general rule, in cities of this class (less than 10,000 inhabitants), where no paving has been done and no fixed policy determined, bids are called for upon several types of pavement, and the final selection is made upon a basis of cost and engineering advice as to adaptability for existing conditions. It is therefore common practice for engineers in this part of the country to prepare specifications covering various types of pavements rather than to restrict the bids to a single type.

I will give a few notes covering pavements actually constructed during 1919, under specifications drawn by this office, or contracted for during the present year, up to the present time. Out of a total of 575,000 sq. yds. of pavements contracted for between March 20, 1919, and February 17, 1920, covering 10 cities of this class, 255,000 sq. yds. were reinforced concrete, 45,000 sq. yds. were asphaltic concrete, Class A, and 275,000 sq. yds. were asphaltic concrete, Class B.

The matter of laying water and sewer house connections to vacant lots and the replacing of old galvanized water service pipes with lead, together with the proper protection for steam heating mains, gate valves, etc., is work of a routine nature, which must always precede paving and need not be touched upon in detail here.

Width of Roadway

The first matter of importance for the engineer to determine is the width of the roadway on the streets. For a main street, 100 ft. in width between property lines, 15-ft. walks, with a 70-ft. roadway, works out very well, while for an 80-ft. street, 12-ft. walks and 56-ft. roadways give suitable proportions. Under conditions generally found in cities of this class the walk width on each side of a business street should be approximately 15 per cent. of the entire width of the street.

For residence streets a minimum width of paving of 30 ft. has been adopted, with 34 to 40 ft. for the arterial streets connecting with state highways in the country. The paved roadways of semi-business streets may vary between the above limits. Where extremely wide streets occur in the residence districts, double roadways are frequently used, with a parkway at the center.

Pavement Crowns and Gutter Slopes

The pavement crowns vary with the type of pavement and the grade of the street. For concrete pavements the crowns vary from 0.5 ft. for a 30-ft. width to 0.75 ft. for a 70-ft. width. For asphaltic concrete pavements the crown varies from 0.55 ft. for a 30-ft. width to 0.85 ft. for a 70-ft. width. For steep grades the crown is somewhat less than the figures just given.

Experience has shown that where the gutter slope is less than 0.8 ft. per block of 300 ft. the drainage is unsatisfactory, consequently with flat grades the normal curb exposure of 6 ins. is varied to obtain the necessary fall.

In cases where trunk roads of the state highway system pass through these cities, the plans and specifications are submitted to the State Highway Commission for approval, so that upon passage of the proposed Babcock Amendment cities may arrange with the various counties to receive a portion of the refundment of State and Federal Aid.

Drainage

The matter of sub-drainage is as important with city pavements as with country roads, and in some places it

is common practice to lay tile drains adjacent to the curbs. However, in cities where both storm and sanitary sewers have been previously laid, there is a question as to the advisability of incurring additional expense for tile drainage, as the existing sewers will be quite effective in draining the soil, especially after the pavements are completed and proper surface drainage has been provided.

In a strictly business district the entire area is covered with buildings, pavements or sidewalks, leaving very little access to the tile for surface water, and in a residence district with properly sloped boulevards, surface water quickly finds its way to the pavement, gutters, and thence into the storm sewers.

There is also the additional subsoil drainage obtained by sewer trenches and house connection ditches, as nearly all engineers are familiar with the lowering of ground water level which takes place after the construction of a sewerage system, most of this lowering being due to indirect entrance to the sewer system through pipe joints. Although there are cases in heavy soil where tile drainage for city pavements is beneficial, in many instances it is an unnecessary expenditure.

Grading

The grading includes the making of fills, the removal of all material between curb lines, the preparation and rolling of the sub-grade ready for the laying of the pavement proper, together with the removal of all crossings, gutters and culverts.

Excavation is paid for on a cubic yard basis, the price bid including all of the above items. Excess material not placed behind the curbs or used for filling boulevards is hauled away, overhaul being paid for at the rate of 2 cts. per cu. yd. per 100 ft., over a free haul of 1,000 ft.

The sub-grade is brought to a firm, unyielding surface by rolling with a 10-ton roller. By using a roller of this weight, soft spots in the streets, due to new and old ditches, are compacted and danger from future settlement avoided. Where fills are made all vegetable or perishable matter is removed from the top surface, the fill deposited in layers not more than 12 ins. in thickness, and the surface passed over at least twice with the roller.

Curbs

Alternate bids are generally received upon two or more types of curbs. Type A is a standard curb, 6 ins. wide and 17 ins. deep. Type B is a special curb generally used in the business section and on filled streets. It is 6 ins. thick at the top, with a 1:12 batter on the front face, and a depth varying with conditions. Type C curb is a 6-in. integral curb which is used only in connection with reinforced concrete pavements. Type D curb is a combined curb and gutter, consisting of a 6-in. curb with a 2-ft. gutter apron. This latter type is used more particularly with pavements having an asphaltic wearing surface, and its use is confined principally to residence districts.

The mixture specified for curbs is a 1:2½:4½ mix, using approved crushed rock or screened gravel for coarse aggregate, or a suitable mixture of pit-run gravel, based upon the proportions given in the following table:

PROPORTIONS FOR PIT-RUN GRAVEL

Ratio Pebbles Retained on No. 8 to Pit-run	Use		Use		
	Sacks Cement	Cu. Ft. Pit-run Gravel	Sacks Cement	Cu. Ft. Pit-run Gravel	Cu. Ft. Screened Gravel
.66	1	5.00	1	5.00	0.00
.60	1	4.65	1	4.65	0.44
.55	1	4.39	1	4.39	0.76
.50	1	4.16	1	4.16	1.05
.45	1	3.94	1	3.94	1.33
.40	1	3.75	1	3.75	1.56
.35	1	3.57	1	3.57	1.79
.30	1	3.41	1	3.41	1.99
.25	1	3.27	1	3.27	2.16

After the concrete has been poured and has stiffened sufficiently, the forms are removed and the top surface and exposed face troweled to a smooth and uniform surface. The surface of the gutter for the Type D curb is finished with a 1:2 Portland cement mortar ½ in. in thickness, which is put on immediately after the concrete has been placed.

Expansion joints ⅜ in. wide, extending through the entire thickness of the curb, are placed in the curbs in line with the transverse expansion joints in the concrete pavements and at intervals of about 30 ft. for other pavements. Radius curbs varying from 2 ft. radii at alley returns on business streets to 15 ft. or 20 ft. radii at residence street intersections, are used.

Reinforced Concrete Pavements

Reinforced concrete pavements both 6 and 7 ins. in thickness have been constructed, the thickness depending upon the soil and traffic conditions. The cement used is required to meet the latest specifications and tests for Portland cement adopted by the American Society for Testing Materials. The contractor provides for inspection at the mills by a reliable testing bureau, and includes the cost in his bid, this bureau furnishing certified copies of the mill tests of each shipment to the engineer.

The fine aggregate is clean, hard sand, free from clay, loam or other deleterious matter, and when tested by laboratory screens must meet the following requirements:

Passing a ¼-in. screen.....100 per cent.
Passing a 20-mesh and retained on the 50-mesh sieve .....30 to 65 per cent.
Total passing 50-mesh sieve, not more than..20 per cent.
Total passing 100-mesh sieve, not more than. 5 per cent.

Alternate bids were formerly received, based upon using crushed granite, trap rock or quartzite or screened gravel, but recently the bids have covered the following three classes of coarse aggregate: First, Class A rock, consisting of the best quality of crushed granite, trap rock or quartzite, having a French co-efficient of wear of not less than 8 and a toughness of not less than 8; second, Class B rock, consisting of crushed rock, having a French co-efficient of wear of not less than 5 and a toughness of not less than 5, and third, consisting of clean, screened gravel.

The inclusion of the Class B rock was due to the fact that on account of the scarcity of the harder materials, the paving construction would have been cut down considerably had not more available and somewhat softer rocks been allowed.

The concrete for reinforced concrete pavements is a 1:2:3½ mix containing not less than 1.7 bbls. of cement per cu. yd. of concrete for hand finish, or a 1:2:4 mix, containing not less than 1.6 bbls. of cement for machine finish.

It is required that each batch remain in the mixer at least 1 minute after all materials have been placed in the drum, and shall have not less than 12 nor more than 18 full turns of the mixing drum.

Although machine-finishing is covered by several clauses in our specifications, machines have not as yet been developed for suitable finishing of pavements over 24 or 26 ft. in width, and consequently are not as yet in use for finishing city pavements, although they are very commonly employed on country highways.

In hand-finishing, the surface of the concrete is struck off by means of a strike board or is brought to the proper surface by means of grade-pins and floats manipulated by wooden handles. Special care is taken to consolidate the concrete along expansion joints. After the surface is brought to proper grade it is rolled with a split roller approximately 10 ins. in diameter and 6 ft. long, weighing about 75 lbs. At expansion joints the split is opened and the roller operated so that the split will straddle the joint. This operation is to be repeated at intervals of 15 to 20 minutes until no free water is squeezed from the surface. Immediately after the rolling the surface of the pavement is finishd with belts, the surface being gone over twice.

The space along the curb which cannot be finished with a belt is finished with a wooden float. A separate float is used to finish the surface along expansion joints and to better compact the concrete at this place a finish tool is used to finish the edges of the joints to a ¼-in. radius.

After the concrete is sufficiently hardened, the surface of the concrete is kept continuously moistened by sprinkling, and under most favorable conditions the pavement is not opened to traffic for at least 14 days after its completion. Concrete is not mixed or deposited when the temperature is below freezing.

Longitudinal expansion joints are constructed along each curb and also at intermediate points for streets over 55 to 60 ft. in width. Transverse expansion joints are constructed across the pavements at intervals generally not less than 40 ft., and at street intersections running diagonally from the radius curbs towards the center of the street.

The diagonal joints at the intersections are used to eliminate the unsightly cracks which generally radiate from man-hole covers at the center of streets where joints and reinforcement have not been used.

All joints are formed during construction by inserting and leaving in place a joint filler, ⅜ or ½ in. in thickness, extending through the entire thickness of the paving.

No metal protection at the joints is used, but especial care is taken to secure a dense concrete and a true surface next to the joint. The principal objection to joints is the slight impact at regular intervals felt when riding over a pavement with expansion joints, this usually being due, not to the joint material, but to the improper finishing of the surface on either side.

The concrete pavements are reinforced with round, deformed bars, of structural or intermediate grade steel, the total weight of steel being approximately 3 lbs. per square yard. Each separate block between expansion joints is generally reinforced along all edges, with a ⅝-in. round bar laid about 6 ins. from the edge, and through the interior with ½-in. round bars. The bars are placed so that the center shall be 2 ins. below the top of the finished pavement.

Concrete Foundations for Pavements with Wearing Surface

The tendency in Minnesota has been toward the construction of a rigid base for all pavements with wearing surface. The rigid base has the advantage of bridging over any soft spots in the sub-grade, and is suitable to the extreme climatic changes which occur in this region.

In our work in cities of this class a Portland cement concrete base 5 or 6 ins. thick has been specified, alternate bids being received upon the two thicknesses. Crushed rock or screened gravel is used for the coarse aggregate of the base, a 1:2½:4 mix being used for hand-finished and a 1:2½:4½ for machine-finished work.

In order to insure the proper compactness of the concrete in the base, rolling similar to that employed for concrete pavements is required, after which the surface must be gone over with a spiked roller or tamper, so as to provide a proper bond for the wearing surface.

Asphaltic Concrete, Class A

This pavement consists of an asphaltic concrete wearing surface 2 ins. thick, laid upon a 5 or 6-in. concrete base. Natural lake fluxed asphalt or oil asphalt meeting the specified requirements may be used for the bituminous cement. The penetration required for the fluxed natural lake asphalt or the oil asphalt at 25 degrees C. (77 degrees F.) is 55 to 60 for 100 gr. wgt. 5 sec.

The coarse aggregate consists of best quality crushed granite, trap-rock or quartzite, having a French co-efficient of not less than 8 and a toughness of not less than 8. When tested by laboratory screens it must meet the following requirements:

Passing ½-in. screen, not less than..... 95 per cent.
Retained on ¼-in. screen, not less than..... 37 per cent.
Retained on 10-mesh sieve, not less than....100 per cent

The fine aggregate is composed of sound, durable stone particles or of clean, moderately sharp sand, properly graded. When tested by means of laboratory screens the fine aggregate shall meet the following requirements:

Passing a ¼-in. screen.....100 per cent.
Passing a ⅛-in. screen..... 95 per cent.
Retained on 200-mesh sieve, not less than... 95 per cent.

The mineral filler consists of Portland cement and limestone or dolomite dust. Not less than one-half of the mineral filler is Portland cement and not less than 47 lbs. of Portland cement is used in each 1,000-lb. batch of bituminous concrete.

The total mineral aggregate must consist of a uniform mixture of the above ingredients, the grading and proportionate amounts of each being such as to give the following proportions:

	Allowable Limits	Desired
Passing 200 mesh	10% -12%	11%
Passing 80 mesh	10½% -12½%	11½%
Passing 40 mesh	10% -14%	12%
Passing 20 mesh	11½% -15½%	13½%
Passing 8 mesh	13% -17%	15%
Passing ¼ in. screen.....	13% -19%	16%
Passing ½ in. screen.....	18% -24%	21%
		100%

After being thoroughly heated to the temperature directed, the bituminous material and the mineral aggregate

is measured and mixed so that the resulting mixture contains from 70 to 90 lbs. of the bituminous cement to 1,000 lbs. of mineral aggregate. When delivered, the bituminous concrete must have a temperature of not less than 225 degrees F.

The mixture is dumped far enough in advance of its final position to insure the load being turned. When rolled and thoroughly compacted it must have a thickness at no place of less than 2 ins. and a weight per square yard of not less than 220 lbs. for each batch, and must be free from surface depressions or irregularities.

Upon completion of rolling, a thin coat of Portland cement is applied with a broom, using 1 bbl. of cement to 1,200 sq. yds. of pavement.

Asphaltic Concrete, Class B

As with Class A, this type provides for a 2-in. wearing surface of asphaltic concrete, laid upon a 5 or 6-in. concrete base. The specifications and requirements for bituminous cement are the same as described for Class A.

The broken stone is of the best quality of crushed granite, trap-rock or quartzite, having a co-efficient of wear of not less than 8 and a toughness of not less than 8. The coarse aggregate must be the product of the crusher, which, when tested by means of laboratory screens, must meet the following requirements:

Passing a 1-in. screen, not less than..... 95 per cent.
Total passing a ¾-in. screen.....35 to 65 per cent.
Retained on ¼-in. screen, not less than..... 95 per cent.

The fine aggregate is composed of sound, durable stone particles or a clean, moderately sharp sand, and, when tested by means of laboratory screens, must meet the following requirements:

Passing ¼-in. screen .....100 per cent.
Total passing ⅛-in. screen..... 95 per cent.
Total passing 40-mesh sieve.....30 to 70 per cent.
Retained on 200-mesh sieve, not less than... 95 per cent.

The mineral filler must consist of limestone dust, dolomite dust or Portland cement. The total mineral aggregate must consist of such a mixture of the coarse and fine aggregate that, when tested by means of laboratory screen, it will conform as closely as possible by weight to the desired proportions as given in the following table:

	Allowable Limits	Desired
Passing 200 mesh	7% - 9%	8%
Passing 80 mesh	6% - 8%	7%
Passing 40 mesh	6% - 8%	7%
Passing 20 mesh	6% - 8%	7%
Passing 8 mesh	6½% - 9½%	8%
Passing ¼ in. screen.....	6½% - 9½%	8%
Passing ½ in. screen.....	14% -20%	17%
Passing 1¼ in. screen.....	34% -42%	38%
		100%

From 70 to 90 lbs. of bituminous cement for each 1,000-lb. batch of mineral aggregate is required. This mixture is spread and rolled as previously described, so that after rolling it has a thickness at no place of less than 2 ins., and a weight of at least 240 lbs. per square yard for each batch.

As soon as possible after the rolling of the mixture has been completed, and while the surface is still warm and clean, a seal coat of asphaltic cement is spread over the surface, sufficient in amount to fill the surface voids. Over this seal coat is spread a dressing of clean stone chips, this covering to be broomed and rolled into the surface, a small surplus being left to wear away by traffic.

Creosote Block

Previous to the war a number of the smaller cities had laid several blocks of creosoted wood block pavement in the business districts, where subject to the heaviest traffic, and there has generally been a tendency to consider this type when bids have been received since the war. This pavement, as specified, consists of a creosote wood block laid upon a pitch filler on a concrete base, alternate bids being called for, using 3 and 3½-in. blocks. On account of the high prices bid for this type of pavement, however, very little has been constructed during the past year outside of the larger cities.

As previously stated, bids have been asked for upon other types than those which have been herein described, but on account of the high cost during the past two years, and because the cities of this class in this region are in the early stages of pavement construction, the types generally bid upon are those of simple construction and of lower cost. Decreasing cost and growth of paving construction will see the use of other types. The contracts let for paving, grading and curbs up to date this season have averaged approximately 35 per cent. higher than those contracted for during the season of 1919. The reasons assigned by contractors for this increase in price are: first, increase in cost of materials; second, higher labor cost; third, transportation shortages and delays, and, fourth, general uncertainty of industrial conditions.

These conditions indicate that if the program of hard surface roads is to continue, a much greater store of the necessary material, such as rock, gravel, sand and cement, must become available at reasonable prices, and wherever possible specifications should be so drawn up as to allow the use of local materials suitable for paving purposes, as the supply of high-grade crushed granite, quartzite and trap-rock is localized.

The foregoing matter is the major portion of a paper by Mr. Shepard, presented at the recent annual meeting of the Minnesota Surveyors' and Engineers' Society.

BITUMINOUS SURFACE TREATMENT OF BROKEN STONE ROADS

By Wm. W. Cox, County Road Engineer-Manager of St. Clair County, Port Huron, Mich.

The success of bituminous surface treatment of broken stone roads, depends upon the character and quality of the road, the selection and purchase of bituminous material, the preparation of the surface of the road, the subsequent application of the material, and the follow up or patrol maintenance.

The broken stone road should be constructed in the best possible manner, with good drainage, of the best possible grade of stone, and with chips properly keyed, rolled, watered and bonded, and with a slightly-crowned, smooth surface. In other words, bituminous surface treatment will not be a success on a yielding or poorly constructed road. A new road should be allowed to season as long as possible without damage by traffic, before it is given

the bituminous surface coating. If the road will stand a year without ravelling so much the better. Before surface treatment is given any road, its surface should be in a good hard smooth condition, or else the treatment is certain to be a failure.

On broken stone surfaces, the use of bituminous materials has been very satisfactory where proper materials were used, and where proper application was made. Oils are not suitable for general use in bituminous surfaces, because the medium heavy oils usually require too long a time to set up, and because most petroleum products act to a certain extent as lubricants, therefore they have a tendency to become rutted and bunched.

Favors Cold Applications

Asphalts and refined tars have been used very successfully as cold applications, and while they have been used as hot applications with varying degrees of satisfaction, yet the cold applications are the more satisfactory and dependable. When they are applied cold they should contain volatile fluids which serve only as the carrying agent. The objection to using hot bituminous material is, that they too readily become chilled when coming in contact with the road, and thus do not give the essential adhesion to the stone. If it is desired to use them as hot applications, the road should first be treated with cold bituminous material which is allowed to set or season, and thus afford a bond between the stone and hot material.

Bituminous materials should be purchased under proper specifications, with a furnished sample, which should be analyzed in the laboratory to determine if it satisfies the requirements of the specifications. When materials are delivered they should again be sampled and tested before being used. This procedure will protect the purchaser against inferior or unsuitable products, and against failures in his surface treatment work.

Prepartion of Surface to Be Treated

After the proper bituminous material has been selected and obtained, great care should be exercised in the preparation of the surface for treatment, because the success of the application fundamentally depends upon the proper union between the bituminous material and the broken stone surface. If this union or bond is not obtained the coating will shove, bunch, rut and peel off. Penetration is therefore not so desired, as is the adhesiveness of the bituminous material to the stone.

For cleaning the surface the most efficient method of procedure is to sweep thoroughly with horse sweepers, or with stiff hand brooms, the final sweeping to be done with brass or other fine fibre brooms. Care should be taken to remove all dirt, dust or litter clear of the stone, so that the whole stone surface presents a clean mosaic appearance. The broken stone surface at the edges along the berm is often covered with a mat of stone dust and litter which requires shoveling or scraping in order to remove it. Any remaining dust or loose material on any part of the surface will not permit proper adherence. A dry windy day is most suitable for cleaning the road. Too much caution cannot be taken to give a properly cleaned surface. After the surface is cleaned, the road should be closed to traffic if suitable detours can be provided.

Application of Bituminous Materials

Bituminous materials should be applied at the rate of ¼ to ½ gal. per square yard. They should be applied only when the temperature is above 50 degrees Fahrenheit, and when the surface is warm and dry. The methods of distribution most satisfactory are by use of gravity or pressure distributers. Pressure distributers are very much the better because they insure a more even application. When hot application is made the bituminous material should be covered immediately, with 13 to 15 lbs. per square yard of hard clean ¼ to ½-in. stone chips or pea gravel. The gravel or chips should be broomed over the surface and at once rolled with a roller (preferably the tandem type) weighing from 5 to 8 tons. When cold application is used, it is almost necessary that the road be closed unless it is wide enough to allow one-half the width to be treated at a time, thereby allowing traffic the use of the other half. The day following the cold application of bituminous material the surface should be covered with gravel or stone chips, and rolled the same as for the hot application before being opened to traffic.

When it is necessary to use ½ gal. per square yard in order to obtain the proper surface, it is economical to apply this in two operations, a day or two apart, and thus avoid waste. When too much is applied at one time the result is that the middle of the road is covered too thin and the edges too thick.

One important thing to be remembered in connection with bituminous surface treatments of broken stone roads is that a built up mat or wearing course is not the object, but rather a waterproof, dust-proof surface covering is desired. Subsequent treatments should have in view only an amount of material to be used which is needed to seal the surface, or to replace that which has been worn away. As soon as a road is treated and opened for travel, there will often appear patches or spots which will loosen or ravel. These places should be patched at once or they will soon become larger and permit moisture to penetrate the road. In order to insure satisfactory results, the road should be patrolled with a suitable outfit to keep the surface free from holes. When the greater part of the bituminous surface fails, it is best to remove it entirely and reconstruct.

Causes of Failures

The causes of failure of bituminous surfaces are numerous. The failures due to the condition of the road surface, may be primarily due to faulty or poor construction of the road or to improper preparation of the surface, in which are found many pot holes, ruts, dust or dirt pockets, either due to accumulation or to original construction. In many cases the stone has not been properly graded or bonded. Then again in many cases a damp or cold condition of the surface has resulted in failure.

The failures due to materials can be traced back to their faulty physical and chemical properties. They may contain lubricant or volatile constituents which make them unsatisfactory, because they require too long a period in which to set up and as a result they bunch and rut.

The failures due to faulty applications may be due to the use of too small an amount, or to an excess amount of bituminous material. Uneven distribution will also prove a failure. The lack of stone chips or pea gravel will cause the surface to remain sticky and unsatisfactory. The use of fine sand instead of the stone chips or pea

gravel should not be practiced, as there is a great possibility of the covering shoving and bunching, when it is increased in thickness by subsequent treatments.

Bituminous surfaces cannot be expected to be permanent, though by such treatments the water-bound macadam road is greatly preserved and protected.

Having a first class road, by the selection and use of proper materials, by their proper application, and by subsequent maintenance and care there is no doubt that bituminous surface treatment of broken stone roads will be a great saving and help in maintenance, and will at the same time make the broken stone road a very satisfactory road for the present day medium or light traffic.

Acknowledgment

The foregoing paper by Mr. Cox was presented before the recent Short Course in Highway Engineering at the University of Michigan.

RELATION OF GRAVEL SPECIFICATIONS TO PRODUCTION

By R. C. Yeoman, Extension Engineer, Indiana Sand and Gravel Producers' Association, City Trust Bldg., Indianapolis, Ind.

In locating a gravel plant, the gravel producer must first be sure of three things—a market, a deposit of gravel and transportation between the two points. In determining the size of his plant he must consider more carefully the deposit, its character, location, possibilities of extension. To illustrate briefly, in the district around Lafayette, Ind., where a bank from 50 to 200 feet is available, and with excellent transportation facilities, it is economical to build a large permanent steel plant. In the Indianapolis district where the deposits are shallow, underground and limited by the political divisions of the city, a large permanent plant would be uneconomical. The shallow deposits demand a small plant which can be easily moved, and unfortunately the smaller plants are necessarily less efficient than the large ones. However, there are deposits located outside the city where there is plenty of space, and greater plants are economically possible, but not in comparison with the more extensive deposits in the north.

Many Grades Cause Trouble

The market that calls for many grades of material makes trouble for the gravel man, especially where he must content himself with a small plant, his deposit is variable and so is his market. Some days his manufacture runs to sand and some days to gravel, and it often happens that on a day that he has a demand for sand the shovel is digging into a gravel bed, and vice versa. For plant economy he must balance the two or waste. The larger plants can furnish many grades of material but they are affected by the same change of deposit, and the plant manager is always juggling his orders so as to meet this variation.

Accurate Grading Increases Cost

Also specifications requiring accurate grading and careful division of product, affect the economy of production. There are two grades of material that are most common—sand and gravel. For arbitrary reasons, a one-fourth in. screen is used to divide the two. A plant which furnishes these two sizes and is required to divide accurately on one-fourth in. finds it difficult to make speed and accuracy go hand in hand.

A failure to make speed increases the cost. A failure in accuracy of grading may condemn the material. Therefore in making specifications that call for many specific sizes, or one which requires accurate grading, greater expense must be expected. To the engineer the problem may be this for example: For an accurate grading of material he shall pay $1.50 per ton. For one of variable gradation he shall pay 75c a ton. Now it is up to him as an economical problem to decide which of the two will give the best results for the least money. If his extreme requirements are of an experimental nature, the producer hesitates to supply it because he faces the problem of having to return to the old plan should the new requirements fail to bring the results intended. It is the duty of the engineer and producer to get together and work out the standard of speed and accuracy that gives the best material for the least money.

A recent study of the plant conditions in Indiana indicates a very wide difference in the equipment of these plants. A few, as mentioned before, are able to furnish most any kind of material specified, while others are limited to clean material but only a few grades, and then a great number who wash thoroughly but only divide their materials in two parts—sand and gravel. A sudden change of conditions in the smaller plants requires not only a demand from the engineer, but some certainty that there will be market sufficient to pay for the change.

Gravel Plant Conditions in Indiana

A recent study of the plant conditions in Indiana indicates a division of products as follows: For roads, 40%; for buildings, 33%; for ballast, 16%; other purposes, 11%. Amounts of sand and gravel sold indicate a division of 50% to each.

Since the plants are now equipped for handling the above distribution of business, a variation in specification requiring a serious change means additional expense, the amount of which cannot be determined in less than a season's run. However, that is one of the contingencies that the gravel producer must carry to some extent no matter what the conditions are.

Gravel is a very common building material and has been used almost indiscriminately for many years. Local practices in its use have sprung up all over the State and are slow to change.

The advance of civilization is demanding higher grade structures and consequently higher grade materials must go into these structures. Machinery is replacing hand labor, and more refinement is required as the processes of manufacture become more complex.

The road problem particularly is undergoing an important change. Only a year ago Indiana had one road law, which recognized the County Surveyor of each County in the State as an authority in his own district. Today Indiana has three road laws, and while the same

authority is still retained by the county surveyor in regard to the original law, the two new ones have created centralized control reaching through the State to the federal government. The effect of these laws will be to unify the conditions over the state, encourage the best talent, and eventually raise road building to a much higher plane. During the transition, however, the economic value of established customs should be considered.

The New Highway Commission have done much already toward standardizing the engineering of highways in the various counties. Their work is only begun. Producers are anxious that they succeed in bringing about the best road conditions possible. Many changes have been made and more will have to be made. With the proper co-operation between the engineer and the manufacturer, the change can be made without serious difficulty.

I have made a study of 20 typical specifications from various counties in Indiana, and I find that they are written particularly to fit the conditions in their respective counties, and my personal opinion is that a uniform specification, unless quite liberal, would be impracticable at this time.

To Unify Specifications in Middle West

Various associations of material producers are at the present time working in harmony with state highway engineers in the Mississippi Valley endeavoring to unify the specifications as to size and uses. When this work is complete it is expected to be a great step forward, and the very fact that it is a co-operative movement insures its success. I would advise that the engineers and the various local districts of the State watch this movement carefully and join in the standardization when the final details are determined. At the present time they should be careful that their descriptions include the materials which they are expecting to use. They can gain much benefit from the State Highway program in the matter of uniformity and expert opinion, but great care should be taken that some limitation is not made that would, because of market conditions in a very busy year, seriously hold up their program.

The result of another investigation inquiring as to the probable road building program for this coming year, indicates that Indiana proposes to spend three to four times as much in 1920 as in the best previous year. This will change the sales and give the road market the maximum over all other demands at the end of the coming year.

The established sand and gravel producers are making a provision for a possible 50 to 100% increased production over the previous year. According to past experiences this will more than consume all the transportation that will be available, and should there be a shortage of material next year the facts are it will not be due to low production.

The sand and gravel producers are anxious for a uniform product. They are determined on a well-prepared product, and they are willing to make any justifiable advance in the quality of their materials when a market for it is guaranteed, but if the experience of the past two or three years of inadequate transportation and erratic demand continues, the producer will experience difficulty in taking care of his normal share in the program. It is their earnest desire to co-operate, especially with the engineer, on whom much of the responsibility for the coming season's success depends.

The foregoing matter is from a paper by Mr. Yeoman before the annual meeting of the Indiana Engineering Society.

APPROVAL OF HIGHWAY BRIDGE PLANS IN INDIANA

By Wm. J. Titus, Chief, Bureau of Bridges, Indiana State Highway Commission, Indianapolis, Ind.

One of the important features of the work of the Indiana State Highway Commission is to assist the counties in the approval of plans and inspection of construction work as provided by both the County Unit and Highway Commission laws. County engineers are urged to make sufficient investigation of bridge sites to determine the proper amount of waterway and a proper depth of foundations, as a mistake in these may permit the total destruction of the most expensive structures.

It is hoped that the possibility of securing approval of bridge plans by the Highway Commission may help to secure a better type of submitted design at county bridge lettings. So long as there were no definite lines laid down for submitted designs, the conscientious designer was pretty much out of the running. There would always be some other designer who was willing to design a lighter and weaker structure and to take a longer chance that it would not fall down before the contractor succeeded in getting his final payment.

Two Chief Lines of Investigation

In the approval of bridge plans, there are two chief lines of investigation relating in brief, first to the sufficiency of the proposed structure from the broad standpoint of its fitness for the given location, its ability to pass the maximum amount of flood water and to carry the maximum loads which may be imposed upon it, and relating, second, once these points have been established, to its structural sufficiency. There is a very definite plane of demarcation between these two lines of investigation. The points mentioned in the first must be determined from an intimate acquaintance with, or investigation of, the conditions to be met at the site of the structure. In bridges on the state highways we can readily do this work, but in county work we believe that these features should ordinarily be established by the local officials, although I believe there is no reason why we should not, on request, undertake to pass upon this phase of the work.

Required Waterway

In handling this phase of our own work, we determine upon the required waterway by an investigation of a number of other bridges both up and down stream from the given structure, from the character and extent of the watershed, from the highwater marks as shown on adjacent brush and trees and from information from persons living near the stream; we determine the slope and

length of wingwalls from a study of the probable action of flood waters on the approach fills and we select the depths of foundations and make recommendations as to the necessity of driving foundation piling after making some soundings of the stream bed and digging a number of test pits. These test pits are seldom more than 4 or 5 ft. deep and do not give any information as to the desirable length of piling, should they be required. This must usually be determined by driving test piles after the contract is awarded.

Loading

All bridges on state highways are made with 20-ft. clear roadways and are designed to support concentrated loads of one or more road rollers weighing 20 tons each or a uniform load of from 85 to 125 lbs. per square foot of roadway, depending upon the length of span. I realize that these conditions may be somewhat more severe than is desirable for certain second and third class roads throughout the state but would urge that where a permanent bridge is to be built, very careful consideration be given to the probable future uses of the structure and the certain future increase in both amount and weight of traffic. County engineers are particularly urged to see that the foundations of piers, abutments and wingwalls are placed at such a depth below the lowest point in the bed of the stream and spread over such an area that the life of the entire structure will not be in danger.

The work of approving submitted plans will therefore be greatly facilitated if those features which the county engineer should determine are set out in either the plans or specifications. It is not unusual for bridge plans to come in for approval without any loading being specified or any word as to the probable allowable soil reaction. If you suggest that neither of them is known, I reply that it is not possible to design the structure without making some assumption as to both of them. I give below a table showing allowable soil pressures as worked out by the Indiana Highway Commission. These are of course only assumptions and, like prices on roadbuilding materials these days, are subject to revision without notice.

SAFE BEARING VALUES OF SOILS

Character of Soil	Safe Working Loads in tons per sq. foot
Loam, silt or quicksand	.5 to 1
Soft or wet clay	1 to 2
Fine Sand or Medium Clay	2 to 4
Hard dry clay, gravel or coarse sand	4 to 6
Hard-pan or very dry clay	6 to 8
Cemented gravel	8 to 10
Rock (Poor brick masonry)	5 to 10
Rock (Best brick masonry)	10 to 20
Rock (Best Ashlar masonry)	20 to 30
Very hard bed rock	30 to 100

Our standards as to structural sufficiency are in the main those of the U. S. Bureau of Public Roads. The amount and distribution of forces and the maximum allowable stresses are generally set out in our standard bridge specifications. We have no desire to be arbitrary as to the amount of detail shown on the plans, but certainly there should be sufficient information to show quite clearly the exact extent of the work to be done.

Acknowledgment

The foregoing is from the address by Mr. Titus before the recent Purdue Road School.

DETOURS UNNECESSARY WHILE LAYING BITOSLAG ON OLD FOUNDATIONS

One of the obstacles presented in road building is the disposition of traffic during construction work. Generally long and tedious detours are necessary over very poor roads. Despite the fact that it is in a good cause and only a temporary expedient, detouring causes much dissatisfaction among road users and results in strong complaints from that portion of the public. It also causes additional expense to users of a road on account of lost time.

Many of the various types of road construction necessitate a closed road during progress of work and consequently a detour. When "Bitoslag" pavement is laid on an existing foundation detours are unnecessary. The "Bitoslag" mixture sets up immediately after rolling and traffic is allowed to pass over the pavement immediately a load of mixture is spread and rolled. This is an operation which does not require many minutes—in fact, the delay occasioned to road travelers is hardly greater than the time ordinarily lost at a busy intersection in a large city when held up by a traffic officer.

An example of the peculiar ability of "Bitoslag" to withstand traffic occurred during the construction of a Pennsylvania state highway in Luzerne county, near West Nanticoke, several years ago, when a large tractor passed over the pavement immediately after being laid and no evidence was shown that the pavement was injured.

Where a new foundation must be laid detours are, of course, necessary, but the main point of this article is that "Bitoslag" can be laid on old macadam, old brick or old concrete without necessitating detours during construction.

CITY PLANNING IN ST. PAUL, MINN.

George H. Herrold, M. Am. Soc. C. E. Office Engineer, Department of Public Works, St. Paul, Minnesota, was appointed managing director and engineer of the St. Paul City Planning Board, effective March 15, 1920.

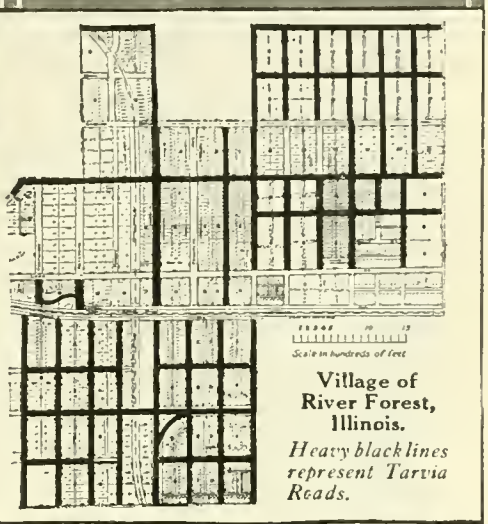
This is a newly created position brought about by ordinances providing for a City Planning Board, to study the physical conditions of the city and prepare a comprehensive plan for its future development.

Also all matters concerning or relating to the platting of new areas or replatting of existing areas; the vacation or rearrangement of boulevards, streets or alleys; the routing or rerouting of street cars and other means of transportation; the assignment of traffic to particular arteries of travel; the location and development of parks, playgrounds, parkways or other public places; the location and design of all public buildings, bridges, monuments and street fixtures; the establishment of building lines; the establishment of restricted building districts; and all other matters relating to the planning or replanning of the city will be referred to the City Planning Board for its consideration and recommendation at such times as the council may direct before final action is taken thereon by the council.

The City Planning Board of Saint Paul has been in existence about a year and has during that time created a public sentiment which has resulted in their securing an appropriation of $50,000 to be expended during the next two years for surveys and a plan.

Oak Ave., River Forest, Ill. Waterbound macadam, maintained with Tarvia.

Augusta Street, River Forest, Ill. Constructed with "Tarvia-X" in 1913.



Village of River Forest, Illinois.

Heavy black lines represent Tarvia Roads.

The Best Streets in Cook County—

IN 1912 the Village of River Forest, Cook County, Ill., began using Tarvia for constructing and maintaining its streets. This is the same County in which the City of Chicago is located.

After seven years of experience with Tarvia, and with Barrett service, Mr. Arthur S. Hatch, Village Clerk, writes us this letter:

> "I wish to express to the Barrett Company my appreciation for the excellent services rendered the Village of River Forest, both as to the Tarvia furnished and the satisfactory application of same to our pavements.
>
> "As you know, nearly every macadam street in our village is treated with Tarvia, and we believe that we have the best streets of any city, town or village in Cook County."

It is one thing for a community to use a road material occasionally for some special purpose. But it is quite another thing—and very much more of a proof of the material's worth—to have the community adopt that material and use it in increasing quantities, season after season, as River Forest has done with Tarvia.

The black lines on the map are most effective proof that River Forest's village authorities and taxpayers alike are strong for Tarvia. Tarvia gives them mudless, dustless, automobile-proof roads at low cost, and after all, that is what every community is looking for, isn't it?

Above Washington Blvd., looking east from "Soo" R. R. viaduct, River Forest, Ill. Waterbound macadam treated with "Tarvia-B" in 1914 and 1916. "Tarvia-A" in 1918 and 1919.

Illustrated booklet telling about the various Tarvia treatments, free on request. Address nearest office.

Special Service Department

This company has a corps of trained engineers and chemists who have given years of study to modern road problems. The advice of these men may be had for the asking by any one interested. If you will write to the nearest office regarding road problems and conditions in your vicinity, the matter will have prompt attention.

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WATER WORKS SECTION

EXPERIENCES WITH AIR LIFT PUMPS

By W. G. Kirchoffer, Sanitary and Hydraulic Engineer, 22 N. Carroll St., Madison, Wis.

Are air lift pumps designed according to the laws of hydraulics and pneumatics or are they guessed at? To one who is not altogether familiar with the principles of these pumps there is a great deal of mystery about them, hence the above question.

Some writers and manufacturers of air lift pumps who profess to understand the mysteries of them would have us believe that the success or failure of the air lift pump depends largely upon the characteristics of the well operated upon. To this assumption (or theory) I cannot wholly agree; my experience has not borne out such contentions. I was much interested recently in reading an article by an engineer of one of the largest air lift manufacturers, published in Municipal and County Engineering for November, 1919. Much that he says is of interest to those who are not experienced in the design and operation of these pumps and such advice as he gives is good. However, I cannot agree with what he contends are the principal causes for failure of a given installation, or his statement as to a master formula. Possibly what he really means is that there is no master formula by which the specific capacity of any and all wells can be determined. To this statement I must heartily agree.

He, like most writers for engineering journals, does not give all the facts and secrets of the business; he leaves much to be guessed at. I can see no disadvantage to the engineer or manufacturer in "laying all the cards on the table face up."

Analysis of Data in a Former Article

In the above mentioned article the author gives as illustrations of his contentions, the installation of two air lift pumps, both on wells apparently alike, but which proved to have widely different characteristics. In the case of the Texas well that produced 530 gals. per minute with 30 cu. ft. of air which he says is phenomenal, let us analyze the data given and see what we find. If we refer to "Compressed Air," by Elmo Harris, page 80, we will find that by substituting gallons per minute for cubic feet per minute and allowing for no losses, we would have for 100 per cent. efficiency, the following formula:

$$V_a = \frac{h}{580 \log \left(\frac{s+34}{34} \right)}$$

in which V_a equals cubic feet of air per gallon, h equals lift and s equals submergence. This formula is derived on the assumption that the work done by the air in expanding isothermally is equal to the work done on the water and neglecting frictional losses. If in this formula we insert the values given for the Texas well h equals 20 and s equals 200 minus 20 equals 180 ft., we will find that V_a equals 22 8 cu. ft. That is to say, if there were no losses whatever, it would require this amount of air to produce 530 gals. of water per minute. If we neglect the losses that might occur in the foot piece (patented part) and consider only the entrance, pipe friction and exit (velocity head) losses, based on hydraulic tables for flow of water, we would find that the entrance losses were 0.31 ft., the frictional loss 8.08 ft. at bottom, 12.2

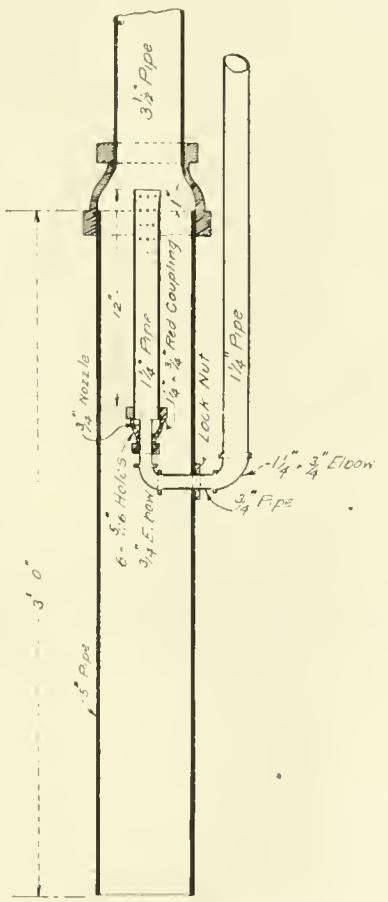

FIG. 1. AIR LIFT PUMP AT WISCONSIN STATE PRISON.

at top, average 10.14 ft., exit loss 0.97 ft., total 11.40 ft. See Hazen and Williams, tables page 24.

The amount of air required with these losses considered is 35.6 cu. ft. There are other losses which we have not considered which must certainly exist, such as loss by impact in the foot piece, slippage of water past the air, loss of head, etc.

It, therefore, would hardly seem consistent with good scientific reasoning to credit the 30 cu. ft. of air with having pumped the 530 gals. of water per minute. What probably happened is that the 30 cu. ft. of air increased the velocity of the water in the well to such an extent that the natural flow was greatly increased because of the opening of crevices and the cleaning out of the well. Or it may be that the compressor actually produced more air

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than the above mentioned 30 cu. ft. At a water works plant in Wisconsin, where I was engaged to design and superintend the addition of an air lift pump on a flowing well, the application of the air increased the natural flow after the air was shut off.

If we are to analyze further the installation we will find that the per cent. of submergence is 90, greatly in excess of that actually needed or recommended by the best authorities. According to bulletin 71A of the Sullivan Machinery Co., page 15, the submergence should be 70 per cent. to 66 per cent. for this installation. These percentages would give the actual submergence from 47 to 39 ft. The pressure required under these assumptions would have been 21 lbs. to 16.9 lbs. That actually used was 78 lbs.

The actual horse-power required to compress 30 cu. ft. of air under the conditions as installed was 4.68 H. P. That which would have been sufficient under an economical installation would have been $(6.38 \times .30) = 1.9140$ H. P. From the standpoint of economy, was the installation so very remarkable after all? It is evident in this case, efficiency was sacrificed for the sake of quantity. As to the weaker well cited at Fort Dodge, Iowa, I contend that had the flow of the well been confined in a pipe and the height to which it would rise determined, or better yet, a test with a small pump applied, they would have found that the well had no relation to the well in southwest Texas.

My experience with air lift pump installations would lead me to believe that they have been made more on the assumption that because a well of certain size, depth, etc., at one place gave good results, the same size of pump, submergence and other characteristics would do likewise at another installation.

Installation at Platteville, Wis.

For many years I was very much opposed to the use of air lift pumps on account of their reported inefficiency. It was not until the year 1909 that I had the opportunity to test one of them and to write specifications for a new installation at Platteville, Wis. The old air lift pump was a "straight air" installation of 375 ft. of 1¼-in. pipe in a 6-in. well. Water was 110 ft. from the surface. The test consisted of weighing the coal burned and measuring the water pumped into a surface reservoir. It required 30.12 lbs. of coal to raise 1,000 gals. of water.

The new installation was to be in a 16-in. well 1,000 ft. deep and located about 150 ft. from the old well. The specifications gave every liberty to the builder that he might ask for, he being limited only by the size of the compressor on hand, and his guarantee as to the saving in coal he was to make. One of the bids submitted specified that they could save us 25 to 50 per cent. of the coal, would supply 350 gals. per minute and would operate at 70 lbs. pressure. The bid was accepted and the pump installed. The first test showed clearly that the pump was not large enough to produce the 350 gals. per minute at any submergence or at 70 lbs. pressure. This pump was removed and another larger one installed. This was tried out at three different submergences, none of which would work at 70 lbs. pressure or supply the amount of water specified. The best results were obtained when pumping 337 gals. per minute with 381 cu. ft. of air at 102 lbs. However, the consumption of coal was reduced to 15.83 lbs. per 1,000 gals. No doubt, this was partly due to the fact that one well was 16 ins. in diameter and the other 6 ins. The pump was purchased, but it now lies in a scrap heap and a deep well plunger pump is doing the pumping.

Slightly previous to this time I had made a test at Elkhorn on a "straight air" installation. I asked this same company to make me a bid on a better and more efficient pump. I received the proposition all right, but by analyzing it I found their pump would not go inside the well or operate at the pressure specified so I did not recommend to purchase it.

Several similar pumps were installed at a city near Milwaukee, but they all have been replaced by pumps made by the local superintendent who claims his pump to be superior to the patented ones.

Installation at Wisconsin State Prison

This experience so completely disgusted me with any patented foot piece that I did not consider another installation of air lift pumps until in the year of 1917 when I was experimenting on the city water at Wausau for the removal of iron and manganese. I installed five homemade pumps of my own design. These were never tested carefully for efficiency but operated much more steadily than any pump I had then seen, and by rough calculation on compressor displacement, were using a very small quantity of air per gallon. Shortly after this I was called upon by the chief mechanical engineer of the state of Wisconsin to advise him on the air lift pump that had been installed at the Wisconsin state prison. This well is 10 ins. in diameter and about 800 ft. deep. Water stands 31 ft. from the floor level. This pump was equipped with a foot piece patented by engineers at the prison and consisted of a cone shaped casting with small nozzle in the center. This was placed in the well 132 ft. from the top. It required 85 lbs. pressure with compressor running at full speed to raise 158 gals. per minute. The lowering of the water was 13 ft. 4 ins., the total lift about 60 ft. and the submergence 72 ft. I therefore recommended a new installation based on my experience at Wausau. The foot piece was made entirely of pipe and fittings and consisted of a piece of 6-in. pipe 3 ft. long with nozzle made of 1¼-in. pipe. The top of the 1¼-in. pipe was flared out to a thin edge and the increaser at the bottom was drilled with six 5/16-in. holes to allow water to enter the 1¼-in. pipe about the ¾-in. air outlet. See Fig. 1.

The theory of this nozzle was that by mixing a small quantity of water with the air an emulsion would be produced which would be more efficient than just large "bubbles." This pump was installed and tested very carefully with the result that with compressor operating as before but with a pressure of only 55 lbs., 245 gals. per minute were discharged. This was such a material gain over the former foot piece that I became much more interested in the air lift pump and began a scientific as well as a practical investigation of the workings of these pumps. Mr. John C. White, Capitol Power Plant Engineer, did not take much stock in my emulsion theory of a mixture, so he built a pump in his power plant of 2½-in. pipe, 65 ft. long. He made a foot piece of cast iron with plate glass windows on each side so that we could observe the action of the air and water in the nozzle. See

Fig. 5. He also built a meter for measuring the air as it entered the foot piece. Several test runs were made simply for observation purposes, but later it was decided to run two series of tests, one with the nozzle to break up the air into fine bubbles such as I had used at Wausau and one with a single large opening which Mr. White contended was just as good.

The water was measured by a 1½-in. water meter properly tested. Thirty-five sets of readings (10 in each set, total 350) were made on each nozzle. The water pumped varied from 12 gals. per minute to 60 gals. per minute and the submergence from 30 per cent. to 75 per cent. The results were reduced so as to show cubic feet of air per gallon. From these 700 observations the following deductions were made.

Deductions from Tests

Out of these comparative tests in which the gallons per minute pumped and the submergences were the same for each nozzle, 40 per cent. of these were in favor of the straight nozzle by an average of 0.02444 cu. ft. of air per gallon. The maximum difference was 0.3485 and the minimum 0.0006 cu. ft. per gallon. Sixty per cent. of the tests were in favor of the special nozzle (designed to produce fine bubbles) by an average of 0.0232 cu. ft. of air per gallon. The maximum difference was 0.0915 and the minimum 0.0023 cu. ft. of air per gallon.

During the test, observations were made on the operation of the nozzles. Instead of the water entering the special nozzle at the bottom, air came out when high velocities were used. The bubbles, however, were small and numerous. Observations made on a pump entirely of glass revealed the fact that no matter how fine the bubbles were at the foot piece, they soon joined into large ones a few feet above the point of entrance.

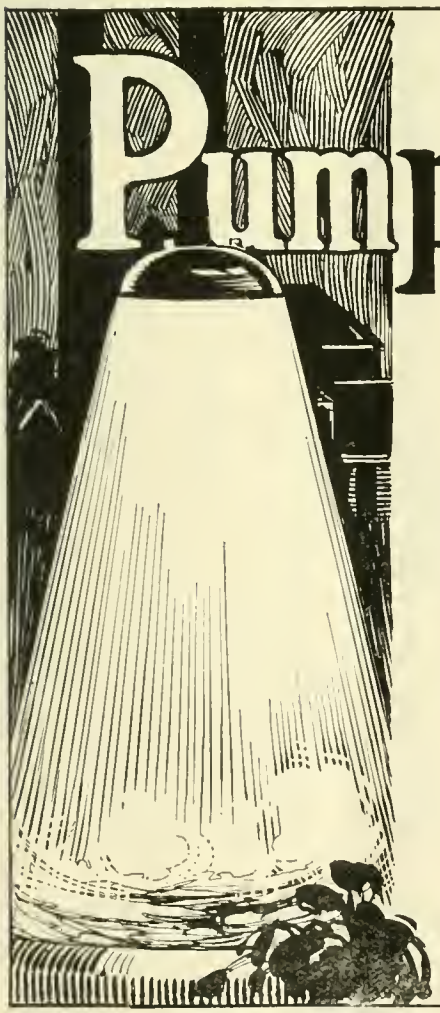
These tests would appear to prove quite conclusively that any attempt to break the air up into fine bubbles is useless, that a plain straight open nozzle is as good as any foot piece that uses a nozzle at all. Professors Corp and Ward, of the Hydraulic Laboratory of the University of Wisconsin, became interested and directed the tests.

These tests were then followed with several hundred more observations to determine the loss of head in the eduction pipe and to find the submergence and capacity for highest efficiency with an 2½-in. eduction pipe which tests have not as yet been completed and made available for publication.

Installation at Southern Wisconsin Home, Union Grove, Wisconsin

During the time these tests were in progress I was called upon to design a pump for the Southern Wisconsin Home, at Union Grove, Wis. This well was 10 ins. in diameter to a depth of 255 ft., 8 ins. to a depth of 800 ft., and 5 ins. to a depth of 1,065 ft. Before pumping the water stood at 120 ft. and during a pumping test lowered to 165 ft. and produced 62.6 g.p.m.

An air lift pump was designed for 60 gals. per minute



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and consisted of a home-made foot piece of pipe and fittings similar to the one used for test purposes. Eduction pipe was composed of 200 ft. of 2-in. pipe, 122 ft. of 2½-in. pipe and 45 ft. of 3-in. pipe with increasing couplings between them. It was estimated that 48 cu. ft. of air per minute would pump this amount of water and that the pump would operate at 95 lbs. pressure. On completion of the installation the pump was tested and found to deliver 64.4 gals. per minute with 48 cu. ft. of air.

Installation at Mendota State Hospital

At Mendota State Hospital a rotary deep well pump was replaced by one of these pumps. Here the well conditions were 15-in. well 700 ft. deep. Water stood at 89 ft. from the surface. The new pump was designed to discharge 300 gals. per minute with 175.5 cu. ft. of air under a pressure of 69½ lbs. This installation being so near the University of Wisconsin and the Capitol Power Plant, we made a very careful test with air meter, etc.

Installation at Sparta, Wis.

It was found that 118 cu. ft. of free air at 74 lbs. pressure raised 307 gals. per minute. Recently a similar installation was made at the water works plant at Sparta, Wis. Here a 10-in. well 293 ft. deep flowed about 200 gals. per minute into a ground water well-reservoir. The pump was designed to discharge 500 gals. per minute with 100 cu. ft. of free air at 30.3 lbs. with an estimated lift of 30 ft. Here it was somewhat difficult to make an accurate test because the pump discharged into a ground water well whose filling curve was not known with accuracy. However, a relatively close measurement gave 491 gals. per minute with 100 ft. of air (70 per cent. of volumetric displacement). The lift was about 27 ft.

The above installations were on four wells no two of which had the same static lift or drop of head due to pumping and yet it has been possible to design pumps for them that have produced almost exactly the amount of water, pressure and air consumption that was estimated. All of these pumps were designed with variable diameter eduction pipe and for velocities of 12 to 15 ft. per second at the bottom end of the pipe and 25 to 30 ft. at the top. Would not this brief experience somewhat refute the statement that no master formula could be used for all installations? Would it not also show that what is lacking is proper knowledge of the specific capacity of wells rather than that the master formula is lacking?

Formula Pertaining to Air Lift Pumps

Various attempts have been made to derive formulas to express the relationships existing in an air lift pump. In bulletin 58-L, page 35, of the Sullivan Machinery Co., is given this formula:

$$V_a = \frac{h}{292.5 \log\left(\frac{s+34}{34}\right)}$$

in which V_a = cu. ft. air/gal/min.
h = lift in feet.
s = submergence in feet.

292.5 is a factor which takes care of the losses and is sometimes varied as the lift increases. This same formula is given by Gardner Governor Co. with factor equal to 234. Its form is the same as the one cited above.

This formula, though somewhat empirical, is of the same form that has been derived by Mr. Elmo Harris and is given in "Compressed Air," page 80. The Hudson Engineering Co. a number of years ago also gave a calculus demonstration of the derivation of it. It can, however, be derived in a very simple manner by equating the work done in compressing the air with the work done in raising the water and allowing for a factor to take care of the fact that the apparatus is not 100 per cent. efficient, this formula would be as follows:

$$V_a = \frac{h + h_i + h_f + h_o}{E\ 580 \log\left(\frac{S+34}{34}\right)}$$

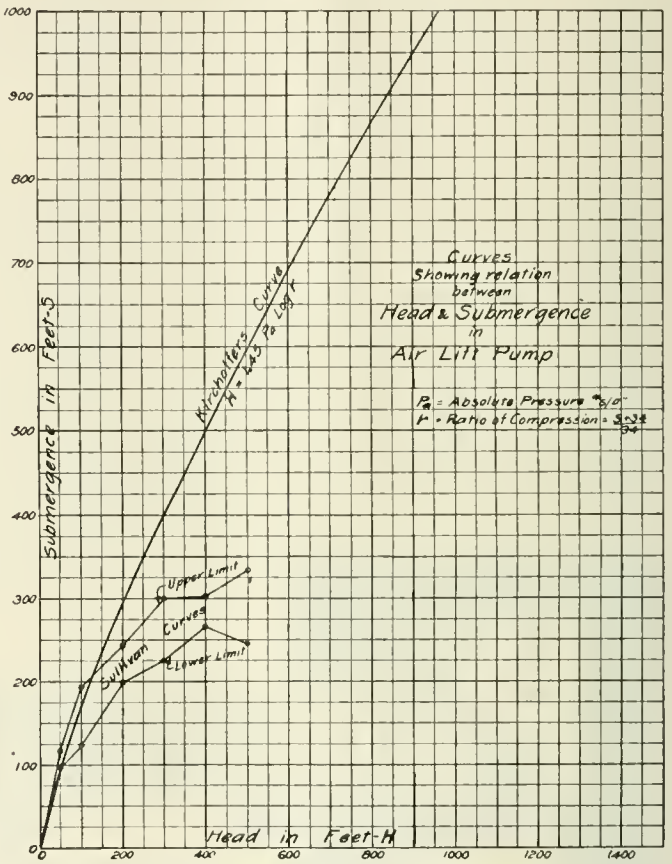


FIG. 2. CURVES SHOWING RELATION BETWEEN HEAD AND SUBMERGENCE IN AIR LIFT PUMP.

In which the factors are as above with h_i equal to the head lost at the inlet of the pump, h_f the head lost in friction of the water and air passing up the eduction pipe and h_o the head lost at the outlet. All of these are unknown and experiments made to determine them have not been given to the public so far as I am aware, but instead the constant or factor "C" has been varied partially to account for them, but cannot be considered as an absolute off-set for them because the diameter of the pipe, the conditions as to roughness and the velocity of the mixtures would all affect h_f. The valve of "C" as determined by the tests at Mendota was 315 and has been used successfully on designs made since. There is no reason why close approximations cannot be made to these by using tables for loss of head in pipes for the flow of water and air.

The efficiency depends quite largely upon the value of V_a for a given installation and upon the submergence. No definite rules have so far been made public for the determination of S for any given value of h which has

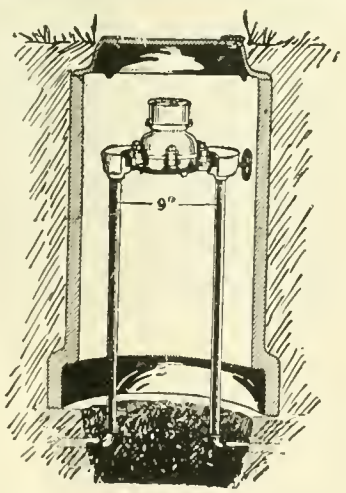
been based on theoretical considerations. Sullivan Bulletin 71-D gives the following table based on experience:

Head in feet	Submergence per cent.
For lifts up to 50 ft.	70 to 66
For lifts from 50 to 100	66 to 55
For lifts from 100 to 200	55 to 50
For lifts from 200 to 300	50 to 43
For lifts from 300 to 400	43 to 40
For lifts from 400 to 500	40 to 33

So far we have been considering the actual volume of free air applied to the pump and have expressed it in terms of cu. ft. per gallon of water pumped. It is to be noted that the volume of free air required per gallon varies with the lift and with the submergence.

From our study of these pumps it would seem to be reasonable to assume that the actual volume of compressed air per gallon of water at the foot piece, for most efficient working conditions, should be constant for all lifts. Such relationship is expressed by the formula $h = C' P_a \log r$ in which $C' =$ an empirical constant derived from experiments, for Mendota pump it is equal to 1.45, h = lift in feet, P_a equals absolute pressure of air at the foot piece in pounds per square inch and r equals the ratio of compression or $\frac{S+34}{34}$. This formula expresses from a theoretical standpoint the relation between h and S.

Fig. 2 shows the above formula graphically for Men-



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Location of Pump	Kind of Pump	Depth of Well	Length of Pump	Diameter of Well	Starting Pressure at Well	Operating Pressure at Well	Cu Ft of Air per Min 71% of Vol of Displacement	Diameter of Eduction Pipe	Gallons Pumped per Min	Cu Ft of Air per Gal	Lowering of Water in Well	Total Lift in Ft	Submergence in Feet	Percentage of Submergence	Efficiency	Static Distance to Water	Constant in Formula for Air per Gal
Platteville	Straight Air	1600	375	6	115	36	302.6	6-1¼	235	1.29	44.0	154	221	59		110'	136
Platteville	Patented Foot Piece	1000	365	16	114	102	381.0	5	3368	1.128	27.7	137	227	69		110'	142
Wis. State Prison	Own Make	800	180	10	57½	49	84.85	3½-5	200	0.425	17.35	63¼	116.65	648	31.275	43.75	230.5
S. H. for F. M.	Own Make	1065	367	8	107½	94	49	2-3½	64.4	0.746	43	165	220	622		119	250
Mendota Asylum	Own Make	700	250	15	75	74	110	3½-5	307	0.303		91	159	636	53.7	89	315
Sparta Waterworks	Own Make	293	115	10	30	37	100	4½-5	491	0.204	27	27	88	76.5		0 ·	315

$V_a = \frac{H}{C \text{ Log } \frac{S+34}{34}}$ Va = Cu ft of Air per Gallon; H = Lift in feet; S = Submergence in feet; C = Constant*

W. G. Kirchoffer, Hyd. & San. Engr., Madison, Wis.

FIG 3. RECORDS OF TESTS OF AIR LIFT PUMPS.

dota pump conditions and its comparison with the Sullivan table.

Conditions Affecting Efficiency

My experience in this practice as a designer of air lifts and with the thousand or more tests I have taken part in, would indicate to me that the losses that take place in the inlet, eduction pipe and outlet, have more to do with the efficiency of the air lift pump than does any form of nozzle in a foot piece. The mistaken idea is often advanced that there is energy in the jet of air that can be used similar to the use made of a water or steam jet. This is a fallacy for the reason that the weight of air used is extremely small and its kinetic energy is extremely small. It is also quite evident from experiments and practice that the eduction pipe, except possibly for low lifts and small quantities, should be of variable diameter with small end down. That any nozzle or other contrivance in the foot piece is an obstruction rather than an aid to efficiency.

Tests are now in progress under the direction of Prof. Ward on a foot piece with no nozzle or other obstruction in it. These experiments bear out the above statement. I also believe that foot pieces should not be made in job lots as other pumps are made, but should be made for each installation to meet the conditions found in the well.

I also believe that where the size and depth of the well will permit, one installation can be made as efficient as another, but the conditions to be dealt with must be known. When gangs of wells are to be pumped by the air lift, interference curves should first be determined.

Promising Future for Air Lift Pumps

I have also changed my mind as to the usefulness of the air lift pump. When properly installed it can be made nearly as efficient as the deep well plunger pump and when considered over a period of years, the total cost of operation, repairs, lack of service (pump out of repair) it would show up better than the average deep well pump. I also believe that air lift pumps in the future will be used extensively for the pumping of sewage and especially so for the removal of sludge from sedimentation basins. My brief experience on the Madison plant convinced me of this fact.

Tests on "Straight Air" Pumps

Sometimes efficiency has to be sacrificed on account of well conditions or because of the necessity for a large quantity of water is more important than efficiency. At Burlington, Wis., I recently tested some "straight air" pumps at the city water works wells. All of these wells were cased with packers at the bottom ends which were held in place by springs engaging the sides of the well.

FIG. 5. TEST PUMP AT CAPITOL POWER PLANT, SHOWING WATER AND AIR METERS, OBSERVATION WINDOWS AND GAUGES.

This construction precluded the installation of the pumps at a sufficient depth to get correct submergence. The size of the wells prevented the installation of eduction pipes with separate air pipes. Two of the wells were changed over from "central air pipes" to central eduction pipes, using the casing as an air pipe. The foot pieces consisted of a short piece of slotted pipe with flaring mouth. In the 6-in. well, the eduction pipe was increased from 3½

No. of Tests	Date When Tests	Operating Pressure at Well	Cu Ft of Air per Min 71% of Vol of Displ	Gallons Pumped Per Minute	Cubic Feet of Air Per Gallons	Air H.P. Delivered to Well	H.P. in Water Pumped	Efficiency	Total Length of Air Pipe	Diameter of Air Pipe	Diameter of Discharge Pipe	Diameter of Well	Depth of Well	Static Distance to Water	Total Lift	Submergence
1	Oct 23-1918	#3-27#	1500	2935	51	11.18	2.20	19.70						30'	19'-20'-42'	89'-71'-66'
2	Mar 18-1919	27	1477.5	3520	42				120'	6-3½	3½-4½	8"		30'	60.0	60.0
3	Mar 18-1919	28	1480	3340	443				120'	6-3½	3½-4½	8"		30'	57.0	63.0

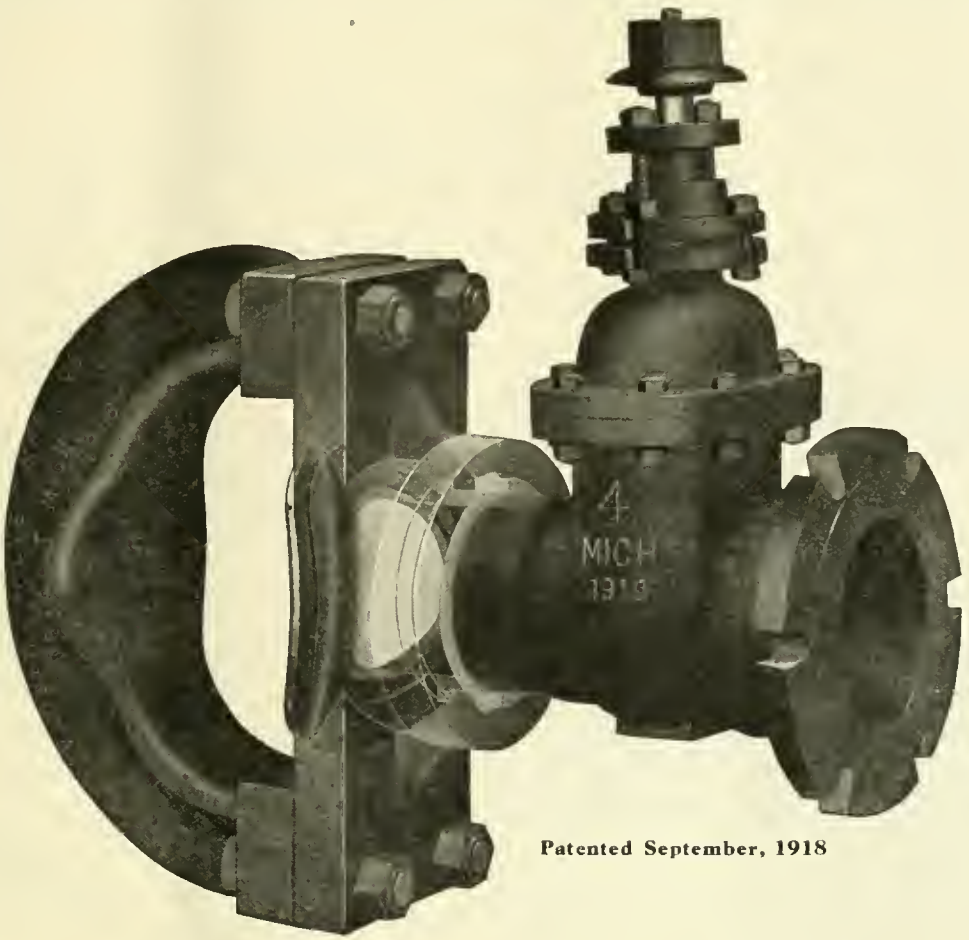
Remarks: Well #3- Bell Mouth only, 4-⅝" Hole, 40' Above#
Well #3- Bell Mouth with 4-⅞" × 8" Slots Above
Well #2- 40'-2" Pipe with ½" Holes in Sides, Bal 1½" Pipe
Well #1- Old Piping, Well Casing Grouted
Well #3- with Holes 40' Up, Well #2 as above#

Water measured in Reservoir 35'-4" × 26'-6" × 12'-6" deep
Capacity per inch of depth 584 Gals

Compressor, Duplex 11" diam × 12" Stroke
Capacity per stroke 264 cu ft

$V_a = \frac{L}{C \text{ Log } \frac{H+34}{34}}$ Va = Cu ft of Air per Gal; L = Lift in Ft; H = Submergence in Ft; C = Constant#

FIG. 4—RECORDS OF TESTS OF AIR LIFT PUMPS AT THE CITY WATER WORKS AT BURLINGTON, WIS.



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to 4½ ins. in diameter. The results of the tests before and after the changes were made are given in Fig. 4. These results are not at all comparable with those for the pumps at the prison, Southern Wisconsin Home, Mendota or Sparta water works as given in Fig. 3.

It is of interest to note the effect of placing four ⅛-in. holes in the eduction pipe 40 ft. above the foot piece in the No. 3 Burlington well. They caused a loss of 18 gals. per minute and an increase in air consumption of 0.023 cu. ft. of air per gallon.

In conclusion I wish to express the opinion that if other engineers, manufacturers and patentees interested in the air lift pump would publish the results of their experiences and tests similar to those given in this article, we might all help to solve some of the difficult problems connected with this work and in the end get something that would be really constructive rather than to continue guessing and dealing in generalities.

PREWAR AND PRESENT REPRODUCTION COSTS OF WATER WORKS

By L. R. Howson, of Alvord & Burdick, Hydraulic and Sanitary Engineers, Hartford Bldg., Chicago, Ill.

Anyone who has had occasion to purchase water works construction materials at reasonably frequent intervals in the past five years has been impressed with the almost continuous upward trend of prices for those materials, along with practically all other commodities. We all know, in a general way, that cast iron pipe, which, prior to the war, varied in price from $25 to $35 per ton, is now costing from $70 to $75 per ton; that brick, formerly $6.50 per thousand, now costs $14, and that labor, formerly plentiful and efficient at 20 cts. per hour, is now getting from 40 to 45 cts. per hour, and is less efficient than formerly. Probably few of us, however, have had occasion to investigate the effect of these increased unit costs upon the total cost of constructing or of reproducing complete water works properties, and it is to throw some light on this question that this paper is prepared, said Mr. Howson in addressing the Illinois Section of the American Water Works Association.

Prior to the war, the most commonly used measure of value in appraising water works properties, was the estimated cost to rebuild or reproduction, using as a basis for the estimate of future prices the average of the prices which prevailed during, say, the five-year period prior to the date of valuation. Obviously, reproduction is a rebuilding process of the immediate future, and the prices used involve a forecast of future prices and construction conditions just as they do in all normal engineering construction; however, in normal times, prior to the war, materials fluctuated in a series of cycles, with a gradually rising trend, and a very good idea of the near future prices was therefore possible by a study of the prices of the five-year period preceding.

Reproduction Costs of the Future

Within the last five years, however, construction prices and conditions have changed, and the question now arises as to where the reproduction costs of the future will probably lie. On several recent boards of arbitration, selected to fix the value of water works properties, two estimated costs of reproduction have been made; one on a prewar basis of unit prices, and the second on the basis of present day prices, and the value reasoned from these limiting estimates.

There are few well-informed people who will contend that prewar prices will ever again prevail in our time, and, accordingly, a cost of reproduction, using prewar prices, represents in all probability a minimum measure of the value of the property.

Most appraisers are also of the opinion that the crest of prices has been nearly or quite reached, and that, beginning soon, there will be a slow and gradual recession in prices to some new level intermediate between the prewar and the present. Accordingly, a reproduction estimate made, using the present price basis, represents approximately the maximum value of the property to those who hold this opinion.

In Table I, herewith, are shown the average prices of the more important water works construction materials which prevailed during each of the years from 1909 to the present. This table simply shows facts with which most of us are more or less familiar.

Table II shows the results of cost of reproduction estimates made for six water works properties during the past year on both the prewar and the present price bases, and illustrates the effect of the fluctuation in unit prices on the total cost of reproducing the property.

In the ordinary water works property from 50 to 75 per cent. of the total value lies in the distribution system, and, for this reason, we have shown in the fourth column of this table the relative proportion of the distribution system cost to the entire plant cost both based on prewar units. The distribution system materials have increased in relatively greater proportion than have other water works materials, and, accordingly, the greater the proportion which the distribution system is of the entire property the greater will be the cost of reproduction at present prices as compared to prewar prices.

The data in this table show that:

1st. For a property in which approximately 50 per

TABLE I—AVERAGE PRICES FOR WATER WORKS MATERIALS, 1910-1920

Material	YEARS									
	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919
Cast iron pipe 6 in. f. o. b. Chicago	$26.92	$24.11	$26.17	$26.83	$24.21	$24.54	$31.25	$54.90	$57.85	$57.97
6-in. valves	12.50	12.50	12.50	12.50	12.50	12.50	16.50	19.50	21.00	22.50
2 nozzle hydrants	25.00	25.00	25.00	25.00	25.00	25.00	34.50	41 50	49.50	49.50
⅝-in. empire meters	10.40	10.40	10.40	10.40	10.40	13.25	14.10	14.10	14.10	14.10
Cross compound pumps per M. G. Cap.	3000.00	2700.00	2500.00	2500.00	2500.00	2500.00	3300.00	7500.00	7500.00	7500.00
Lumber, dealer's price	26.00	26.00	26.00	26.00	24.00	28.00	28.00	40.00	43.00	58.00
Cement (net)	1.25	1.25	1.25	1.25	1.15	1.15	1.43	1.78	2.00	2.00
Brick (Chicago)	6.50	6.50	6.50	6.50	6.50	7.00	7.00	9.00	12.00	14.00
Steel bars	1¾c	1¾c	1¾c	2.1c	1.9c	1.9c	3.5c	6.4c	4½c	4c
Common labor, Central Illinois	20c	20c	22c	22c	22c	22c	25c	28c	35c	40c
Teams	40c	40c	40c	40c	45c	50c	60c	70c	75c	80c

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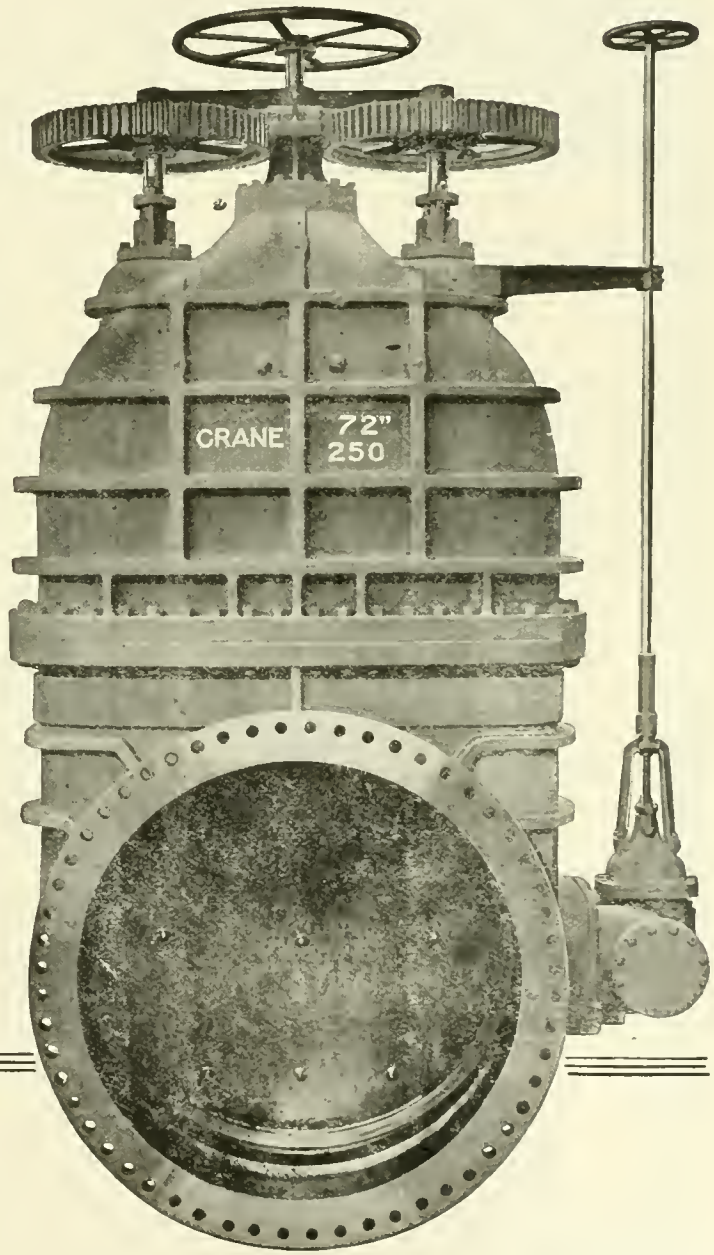

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TABLE II—COMPARATIVE PREWAR AND PRESENT REPRODUCTION COST OF WATER WORKS

Plant	Population Served	Tons of C. I. pipe per 1,000 population	Per Cent. distribution system of total cost to reproduce, prewar	Costs of Reproduction				
				Cost of pipe per ton	Prewar	Cost of pipe per ton	Present	Excess present over prewar
A	92,000	245	58½%	$27.10	$3,700,000	$63.00	$6,400,000	73%
B	8,500	217	79%	29.00	280,000	57.05	503,000	80%
C	10,000	286	61%	28.00	264,000	55.00	444,000	68%
D	12,000	294	77%	28.00	394,000	59.50	689,000	75%
E	25,000	170	66½%	27.10	632,000	68.00	1,192,000	89%
F	25,000	179	46%	27.50	761,000	52.80	1,242,000	63%

With pipe at present price ($66 Birmingham) percentages in last column would be raised to 78% for A, 91% for B, 87% for C, 86% for D, 91% for E, 74% for F.

cent. of the total value prior to the war was in the distribution system, the cost of reproduction at the present time would be approximaely 75 per cent. above prewar.

2nd. For a property in which approximately 75 per cent. of the value was in the distribution system prior to the war, the present cost of reproduction would be approximately double that of the prewar.

Subsequent to the making of these reproduction estimates the costs of lumber, millwork and some other materials have risen which would tend to increase these percentages slightly.

Consideration of Increased Costs Necessary in Valuation

In using reproduction estimates to reason out the valuation of utility properties, several fundamental requirements must be complied with. Among them are:

1st. The kind of service afforded by the utility must be needed by the public in the future.

2nd. The utility being valued must be capable of supplying the service desired, economically, for the present, and be capable of economical enlargment to supply for the future.

3rd. The service must be supplied by the utility at a lower cost than that at which the individual could supply himself with equivalent service.

4th. The public need for the utility in the near future must be a stationary or increasing demand, and not a decreasing one.

When these fundamental conditions are satisfied, a cost of reproduction estimate, carefully made, using the reproduction conditions and prices which will probably prevail during the period of rebuilding and as well continued over a reasonable future period for which the rates are to be in practicable effect, furnishes the best index or measure of the future value of the property and it is to be noticed that it is the future value that we want to know. There is undoubtedly much difference of opinion as to just where the prices of the next few years will fall; however, there cannot be much disagreement with the statement that they will lie somewhere between the prewar normal and the present prices, and the consensus of opinion seems to be that they will lie closer to the present prices than the prewar prices for a considerable time to come.

RESULTS OF PITOMETER SURVEY OF THE EVANSVILLE, IND., WATER SYSTEM

By Charles Streithof, General Superintendent, Department of Water Works, Evansville, Ind.

In August, 1919, after a careful check had been made of the water pumped to the city of Evansville, and of that recorded on over 7,000 meters, including all large consumers, the management of the water department decided to have a survey made of the water distribution system by the Pitometer Company of New York. A preliminary survey was commenced on September 4, 1919.

Method of Making Pitometer Survey

The method of making the Pitometer survey is briefly described as follows: A certain section of the mains is isolated by closing all but one of the boundary valves. A special corporation cock is inserted on the main feeding this district, through the open valve. The main is traversed and the velocity of the water determined by the instrument inserted in the main through the corporation cock. Gaugings are recorded on photo recorders for 48 hours, and from the velocities shown the flow is computed, and as all the water entering this section passes the instrument the amount measured must be the consumption of the district. The interesting feature of these records is the relation between the minimum night rate which is usually found between 11 p. m. and 3 a. m., and the total 24 hour consumption. A high night rate, unless accounted for, means leaky fixtures or breaks in mains. In our case, however, it meant that someone was getting something for nothing.

The night consumption was estimated from 6 p. m. to 6 a. m., and the day consumption was estimated from 6 a. m. to 6 p. m.

Two districts were selected, one in the north end of the city, consisting of 110 city blocks. This district is residential and in it are located twelve manufacturing plants and two packing houses.

District No. 2 is in the heart of the city, where the main piping and surface piping are about 50 years old. This district is composed of 42 city blocks. The district includes a large portion of the business section, hotels, theaters, churches, city hall, police and fire stations, hospitals and clubs, and a great many residences, of which only a few are metered.

Pump Slippage

A 24 hour measurement of the flow of water was made on the two 30-in. mains supplying the distribution system, as near to the pumping station as practical, in order to obtain a total consumption and also test the pumps for slippage.

The results of the tests for slippage were as follows:

Discharge by pump counters. . 10,245,600 gals. per 24 hrs.
Pitometer measurement ..... 10,102,000 gals. per 24 hrs.
Slippage ..... 143,600 gals. per 24 hrs.

From the above figures it will be noted that the slip on the pumps was less than 1½ per cent.

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Results of Preliminary Survey

District No. 1 was isolated by closing all valves excepting one 12-in. valve. This line runs near all the manufacturing plants, and the results of the tests were as follows:

Average daily consumption.....1,018,000 gals.
Minimum night rate ..... 750,000 gals.
Per cent. of night rate to day rate..... 73.6%

The results of our test were as follows:

350,000 gals. per day in the 12-in. main on Morgan Ave.;

175,000 gals. per day distributed through 110 blocks of 6-in. and 24-in. mains in the remainder of the district.

The 350,000 gals. per day on Morgan Ave. were accounted for as follows:

129,000 gals. per day industrial use, metered;

36,000 gals. per day Evansville Packing Co., 6-in. meter;

185,000 gals. per day Evansville Packing Co. passing through the above 6-in. meter but not being recorded.

Meter Found Not Registering a Large Flow

Three different tests were made at this plant at different times to verify the above results:

Test No. 1: Pitometer showed 231,000 gals. per day passing through main; meter showed 46,000 gals. per day passing through main; discrepancy, 185,000 gals per day.

Test No. 2: By closing the valve on the 6-in. supply to meter, pitometer showed 214,000 gals. per day passing through main; meter showed 41,000 gals. per days passing through main; discrepancy, 173,000 gals. per day.

Test No. 3: Pitometer gauging point at the meter, pitometer showed 242,000 gals. per day passing through main; meter showed 64,000 gals. per day passing through main; discrepancy, 178,000 gals. per day.

Result of Test No. 1: While the pitometer showed that water was flowing into the plant at the rate of 444,000 gals. in 24 hours, the meter registered at the rate of 266,000 gals. in 24 hours, or a discrepancy of 178,000 gals. in 24 hours.

Result of Test No. 2: While the pitometer showed that water was flowing into the plant at the rate of 360,000 gals. in 24 hours, the meter registered only 153,000 gals. in 24 hours, or a discrepancy of 207,000 gals. in 24 hours.

The 4-in. meter at the same plant had not registered since the reading taken in October, 1918. The consumption for the last month this meter was in commission was approximately 250,000 gals. for the 30 days, or an average of 8,000 gals. per day. We not only know they use water through this main by the pitometer tests, but when their supply was shut off at the main at night, they were compelled to call the department the next morning and ask to have this supply turned on again.

It is difficult to say how long this large meter had been under-registering. We do know that, with the meter still registering, although incorrectly, this loss of water and consequent loss of revenue would have continued for an indefinite period, through no fault of the meter reader.

After a series of tests on this meter it was inspected by two meter representatives, and it was found that the gear ratio on the low side of the meter was wrong. At the time of their investigation the meter was 45 per cent. slow. Therefore, taking a very low figure of 175,000 gals. a day as the average discrepancy at this plant, and figuring the total loss for a year, would represent a loss of 63,875,000 gals. At 5 cts. per 1,000 gals. the loss in revenue to the department was approximately $3,200 per annum.

District No. 2 is, as explained heretofore, in the heart of the city. This district was isolated by closing all the valves of the boundary line, and feeding water through a 12-in. line which is located in the center of the district. A gauging point was established at the west end of the district. The results of this test were as follows:

Average daily consumption.....1,043,000 gals.
Minimum night rate ..... 700,000 gals.
Per cent. of night rate to day rate..... 67%

On further investigation the following leaks were located:

A 1-in. connection discharging into an abandoned vault; and three 1-in. services broken off at the mains discharging into sewers.

This ended the preliminary survey. As the results obtained were sufficient to warrant the survey of the entire city, the management of the department entered into a contract with the Pitometer Company for a survey of the entire distribution system of the water department.

Survey of Entire City

The city was now divided into 15 districts, and these districts again sub-divided into two, three or more sub-districts, depending upon the extent of the territory to be closed in. In all districts where gauging points were established for sub-division work a permanent vault was built, covered with an iron manhole, so that at any time in the future tests may be made, without again tearing up the paving. Traverses were made at all gauging points on mains larger than 6 ins. in diameter.

It may be of interest to know that, in a district which is 100 per cent. metered and entirely residential, an average daily consumption was 153,000 gals.; a minimum night rate of 115,000 gals. The per cent. of the night rate to the day rate was 75 per cent. This district was composed of 56 city blocks, all thickly settled.

The results of the test showed that 36,000 gals. were running to waste at a public school building, where the following fixtures were found to be running continuously, night and day: 30 toilets, 14 urinals, 4 drinking fountains, 7 wash stands.

The balance of the water was distributed uniformly throughout the rest of the district.

General Results of the Survey

After the surveys of all the districts were made, it was found that water was being wasted in all public buildings, particularly those supplied with water at a minimum rate, or those who are getting water gratis. Sixty-nine house service connections were found with bad leaks, or broken service connections discharging into sewers. One drain line valve was found partly open. Three fire hydrants were found with drain valves disconnected and water discharging into sewers. Several unauthorized connections were also discovered.

Since the completion of the survey a comparison has been made of the average daily pumpage, showing a reduction of 669,000 gals.

Notwithstanding that the system is 50 per cent. metered, including all large services, and that every manufacturing plant and other industry in the city is working full time and overtime, and that 900 additional services have been added, we think that this service was well worth the money expended for it. By making this survey practically all the valves in the distribution system were operated, and in several instances it was found that pipe lines were not connected, of which the department had no information. All fire services were tested, unknown to the owners. Several illegal connections were found.

Sometime after the discovery of the discrepancy in the large meter the manufacturers made a report, from which we quote as follows: "The 6-in. meter purchased from us some three years ago was shipped from our factory to Evansville, Ind., with a cubic foot register. This was replaced with a gallon register, and change gears shipped from our branch office for making this change. The branch office made a mistake in the change gears, sending register 36 S V 20 in place of register gear 33, and stuffing box gear 33. I changed these gears and had the Pitometer man check the registration. Mr. Streithof witnessed this test, the error being about 45 per cent."

The underground leakage located during the survey amounts to over 500,000 gals. per day, which, at a rate of 5 cts. per 1,000 gals. per day would indicate a saving of $25 per day. This amount does not include the under-registration of meters.

This paper by Mr. Streithof was presented at the annual meeting of the Indiana Sanitary and Water Supply Association.

MUNICIPAL OWNERSHIP OF GAS PLANT AT OMAHA, NEB.

Omaha, Nebraska, with a population of about 200,000, is the largest municipality to acquire municipal ownership of the gas plant. The question of municipal ownership of the gas plant has been under consideration since November, 1907, when a special election was called to sumbit to the public the question of voting bonds in the amount of $3,500,000. This election was defeated, but again in May, 1918, the proposition of acquiring the gas plant by exercise of eminent domain through condemnation court was carried. The city of Omaha and the company had appraisals made which were submitted to the condemnation court. The company had three separate appraisals made and the city had the property appraised by Burns & McDonnell, consulting engineers, of Kansas City, Missouri. The four values placed upon the property were as follows:

Burns & McDonnell, representing the city	$3,760,000.00
W. H. Taylor, representing the company	6,281,000.00
H. C. Anderson, representing the company	5,518,000.00
Wm. A. Baehr, representing the company	5,570,000.00

The above figures represent the depreciated values of the property and include going value. Early in February, 1920, the condemnation court rendered a decision awarding the gas company $4,500,000 as the value of the property, and on March 20, 1920, the city commissioners voted to take over the gas works and its operation at the price of $4,500,000. The city commissioners further voted $1,000,000 as working capital for improvements and extensions.

The appraisal and hearing before the condemnation court has required approximately one year's time, and thirteen years after the original proceedings were started the city of Omaha came into possession of the gas plant, and it will be operated by the municipality under a bipartisan board of directors with a manager in charge of the property. It is anticipated that under the city management the rates will not be increased as has been recently the case with many privately owned and operated gas plants. The same board that now so successfully operates the municipal water plant will operate the gas plant.

HIGH EFFICIENCY CENTRIFUGAL PUMPS

In a pamphlet entitled "High Efficiency Centrifugal Pumps," the De Laval Steam Turbine Co., of Trenton, N. J., has described official tests made by the city of Minneapolis upon a 20-in. De Laval centrifugal pump driven by an induction motor and similar tests made by the city of St. Paul upon two 12-in. De Laval centrifugal pumps driven by synchronous motors. The Minneapolis pump, which discharges 30,000,000 gals. per day against a head of 251.56 ft. showed a combined efficiency of motor and pump of approximately 82½ per cent. and a pump efficiency of 86 per cent. The smaller St. Paul units, pumping against heads up to 185 ft. showed over all efficiencies, including pump and motor, of 78 and 78.4 per cent. respectively and pump efficiencies of 81.8 and 82.2 per cent. These performances, together with favorable contracts for electric power, have resulted in remarkably low costs for pumping water in each instance. This publication should be of interest to all who are concerned with the handling of water by electric power.

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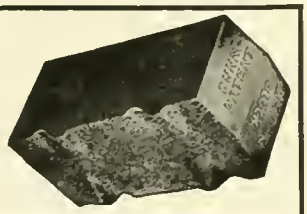

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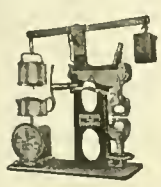

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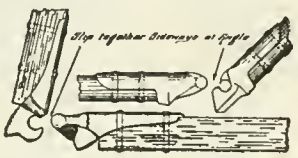

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Construction News and Equipment

CONSTRUCTING CONCRETE ROADS IN NEBRASKA

The road-making material pumped up from the Platte river, in Nebraska, has several characteristics which have heretofore caused engineers to be skeptical about the advisability of using it for concrete paving. That the material may be suitable for this purpose after all is explained in a recent monthly report of the Nebraska Department of Public Works.

A sample of the material was sent to the testing laboratory of the Bureau of Roads, Department of Agriculture, Washington, D. C., to determine whether the so-called Platte river gravel would meet their approval and whether it could be used for concrete paving work in Nebraska. As a result of this testing it was decided to use this material for concrete paving a portion of the Lincoln Highway, 5.94 miles in length, running from Fremont to Ames. This matter was an important one, as it meant utilizing the greatest supply the State has for paved roads.

New Features a Departure from Ordinary Methods

The Platte river runs parallel to this road, and material for the aggregate could be obtained within very reasonable hauls direct from the plants operating along the river in the immediate vicinity of the road. The feature of this road that makes it different from the ordinary construction of concrete roads is as follows:

First. The aggregates used are such a radical departure from the ordinary accepted practice as to excite considerable interest.

Second. The construction methods, while not original, are interesting, owing to the fact that labor has been reduced to a minimum by the installation of the very latest machinery. In this connection it might be well to state that the effluent of the pump dredge carries the sand and gravel to a system of sorting screens and chutes, where the fine and waste materials are returned to the lake pit. The material to be used is delivered into the bins ready for truck loading. The material then hauled to the piles, located at convenient places, and hauling from bins to the stock pile is done by trucks.

Handling Materials Direct by Trucks Eliminates Team Question

Near these stock piles a platform for the storing of cement bags has been erected, and all of the charges for the mixture are carried from the stock piles by means of light capacity trucks. These light trucks are equipped with Lee dump bodies holding 21 cu. ft. They receive a charge of five sacks of cement to 15 cu. ft. of sand-gravel mixture. The sand-gravel mixture is loaded on the trucks by means of an automatic loader. This charge is rushed to the mixer, dumped and the truck returns for another load. The advantages of this manner of handling material from the stock piles to the mixer over the old method of hauling by teams are as follows:

First, the sub-grade is kept in good condition ahead of the concrete. The stock is not stored between the forms, and the action of the oversized tires of the trucks tend to smooth up the sub-grade.

Second. The speed of operation of the truck avoids the confusion and congestion that occur with teams, as many teams must be on the road to handle the same amount of material.

Third. It eliminates the old-time skinner, who sleepily dozed over a pair of mules, and utilizes the young man who is wrapped up in motor vehicles, encouraging him to work at something that he really likes, thus helping to solve, in a measure, the labor problem.

Fourth. Above all, it greatly diminishes the number of men required, and entirely eliminates the team question.

Concrete is mixed in a large ¾ yd. Foote concrete mixer, which is equipped with caterpillar tractors. It distributes the load of the mixer on the sub-grade at a pressure of about 4½ lbs. per square inch.

The ease with which the machine can be moved forward with little damage to the sub-grade makes it an ideal machine for concrete paving. The forms used are Blaw Knox pressed steel, and combine the qualities of a form with a track to receive the finishing machine. The finishing machine used is manufactured by the Lakewood Engineering Co., and is both a money-saver to the contractor as well as a source of satisfaction to the engineer.

No Economy in Building Roads with Antiquated Machinery

This finishing machine automatically cuts out the finished section of the road by means of a steel template attached to the front of the machine. A short distance back of this template is a curved tamper that tamps the road evenly to the exact finished cross section. A belt is mounted behind the machine that rapidly passes back and forth across the pavement, and puts a finish on work that cannot be equaled by hand. The whole machine is motor-driven, and when once started needs no attention except to stop it. Such machinery is a time and labor-saving device, and is one method of building roads economically. It is not economical to build roads with antiquated machinery.

Laboratory Established in Field to Test Materials

The cement is tested, according to the methods of the American Society for Testing Materials, in a laboratory which was established and equipped for that purpose in the field. Sieve analyses are made of the sand-gravel aggregate from time to time. Very close watch is kept on this material to see that it conforms exactly with the specifications. Little variation of the coarser material is allowed, and any deficiency in this respect has to be supplied.

Construction Work Carefully Supervised

The work is supervised by the Nebraska Department of Public Works, aided by the federal government. The State places a project engineer on the work, who is re-

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quired to lay out the work, secure samples of the materials and be responsible for the inspection of the same. He makes a daily report to the department of the materials used and progress made. He is also subject to inspection from the officials of the United States Department of Agriculture, Bureau of Roads, and the state department.

Question of Cheaper Pavements Rests on the Results of This Work

Although this work represents only a small portion of Nebraska's road building program, it is being watched by engineers throughout the Middle West with a great deal of interest, for on the result of this work rests the question of cheaper pavements for some of the Central Western states that have no suitable material for coarse and fine aggregate. The successful use of the Platte river deposit will have a great influence in extending hard surface road systems in Nebraska and adjoining regions.

LIST OF CONSTRUCTION EQUIPMENT USED ON FIFTEEN CONCRETE ROAD JOBS IN ILLINOIS

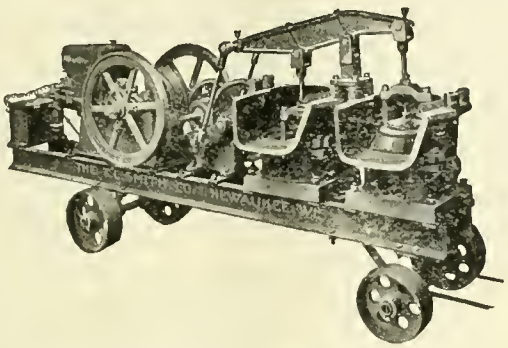
The present article gives a list of the construction equipment used on 15 contracts for the construction of concrete roads in District No. 1 of the Division of Highways of the Department of Public Works and Buildings of the State of Illinois. Mr. G. N. Lamb is District Engineer. The article gives the equipment used in the month of August, 1919.

James O. Heyworth had the contract for sections 4, 5, 6 and 7, in Kane and DeKalb Counties. The water supply was through 35,000 ft. of 2½-in. pipe. There were 3 Novo 6-h.p. pumps. The concrete equipment consisted of 2 Lakewood finishing machines, 2 Koehring 4-bag concrete mixers and 5,280 ft. of Blaw forms. The storage bins for sand and stone each contained 80 cu. yds. and the cement bins held 610 bbls. Each bin dumped 10 batches simultaneously. There was one steam-driven locomotive crane of 20-ton capacity, equipped with a 1½-cu. yd. clam-shell bucket. Two small derricks were operated by steam on the mixer. Five Whitcomb locomotives from 6 to 28 tons in size, with gasoline power, were used. There were 100 Western train cars; 200 Western batch boxes of 0.82 cu. yd. capacity, filled with a spout and emptied with a derrick. The industrial track was 30,000 ft. long, with 7 ties to 15 ft., and of 24-in. gage. There were only 5 wheelbarrows on the job. For subgrade equipment 2 Carr subgrade machines were used and 2 gasoline-driven Austin rollers of 10 tons size. The miscellaneous equipment consisted of 1 elevating grader, 2 5-ft. Fresnos, 4 slips, 4 plows, 6 wheel slips, 2 complete camps and 2 complete blacksmith shops.

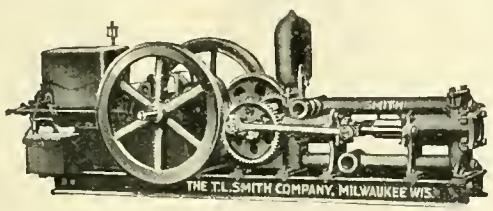
The Illinois Hydraulic Stone & Construction Company were contractors on section 3 in Du Page County. The water supply was obtained through 10,000 ft. of 2-in. pipe pumped by 1 lift and 1 force pump of 2 and 4-h.p., respectively. One Lakewood finishing machine was used. There were 2 concrete mixers, one of Koehring and the other of Smith manufacture, of 2 bag and 1 bag capacity, respectively. There were 1,000 ft. of Heltzel forms.

SAUERMAN
DRAGLINE CABLEWAY EXCAVATORS
Solving Your Gravel-Handling Problem
It is not so difficult to decide what type of equipment is best adapted to your particular sand and gravel proposition if you will bear a few points in mind.
Just remember that a Sauerman Dragline Cableway Excavator will dig over long spans and to any depth, enabling it in most cases to handle the gravel from pit to plant direct without the help of auxiliary conveying equipment.
Remember also that a Sauerman Dragline Cableway Excavator is especially economical and efficient for digging sand and gravel from under water, as witness its frequent use instead of a pump or dredge.
For a specific recommendation on equipment suitable for your operations, write us in detail about your ground conditions, daily output wanted and other requirements of your proposition and we will give you our frank advice.
SAUERMAN BROS.
1142 Monadnock Block, CHICAGO
dig, convey, elevate & dump in one continuous movement under complete control of one man

SMITH PUMPS
The Most Complete Line
of Pumping Outfits in the U. S. A.



Smith Double Diaphragm Pump on Trucks



Smith Outside Packed Plunger Pump

The pump is a vital factor in most construction jobs. Smith pumps are of proven efficiency. You can depend on them. Don't take any "just as good" substitute. Saving a few dollars on initial cost may kill the entire profits on a job by putting 30 or 40 men "down" because of pump failure.

In the complete Smith Line of Pumps you have your choice of the widest variety of types which guarantee efficiency under all conditions—Force Pumps, Diaphragm Pumps, Centrifugal Pumps, Outside Packed Plunger Pumps, Odorless Force Pumps.

Write for Bulletin entitled "NEVER FAILING WATER." It not only contains complete details on Smith Pumps, but gives valuable data on correct sizes of pipes to be used with various pumps, friction tables, etc., which are of inestimable value to every contractor.

THE T. L. SMITH COMPANY
473 Old Colony Bldg., CHICAGO, ILLINOIS
Factories at Milwaukee. Eastern Office and Warehouse at New York

SMITH TILTING MIXERS
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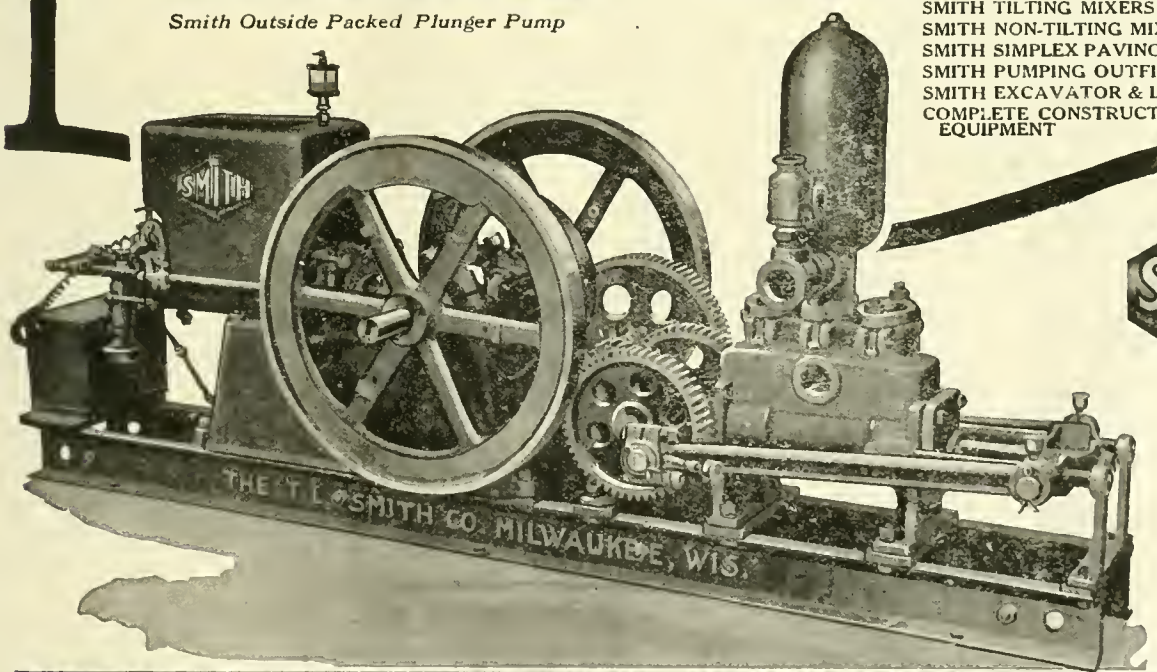
COMPLETE CONSTRUCTION EQUIPMENT



Smith Double Acting Force Pump

SMITH PUMPS

Sand and stone bins each had 90 cu. yds. capacity. Cement was handled in sacks. Home made batch boxes holding 0.4 cu. yds. and numbering 160 were used. They were filled from an overhead hopper and emptied by overturning. Two Holt tractors of 75 and 100 h.p. were used and also one 2½-ton Sandow motor truck was used; also 16 6-ton Troy trailers. One 10-ton, steam, Buffalo-Pitts roller was used on the subgrade. Miscellaneous equipment consisted of 2 slips, 2 wheelers, 3 Fresnos and 2 plows.

The R. F. Conway Company had the contract for sections B, C and D in Will and Cook Counties. Water supply was through 31,600 ft. of 2½-in. pipe and there were five 7-h.p. Gould centrifugal pumps. Three Lakewood finishing machines were used. There were four 4 bag Foote concrete mixers and 8,000 ft. of Blaw forms. One ¾-yd. steam derrick was used. A 55-h.p. Holt tractor was used and 12 motor trucks ranging from 1 to 8 tons capacity and consisted of 5 Macks, 2 Overlands, 3 Whites, 1 Garford and 1 Diamond T. A total of 48 wheelbarrows were used, and two 12-ton steam Castler road rollers. There was also one ¾-yd. Thew steam shovel, 1 Austin grader, 12 wheelers, 12 slips and 12 dump wagons.

F. Lorenz had section 55 in Cook County. The water supply was through 6,600 ft. of 2-in. pipe with one 6-h.p. Olds pump. The mixer was of Ransome make of 1 bag capacity and 500 ft. of wood forms were used. One 1½-ton Ford truck and 5 wheelbarrows completed the equipment on this job.

Blase & Gerken had section 63 in Cook County and obtained water from a city plug. They used wood forms and a 2-bag Ransome mixer. Hauling on this job was let to a sub-contractor and 5 wheelbarrows completed the general contractors' equipment.

Chicago Heights Coal Company had sections 8, 9, 10 and H-15d on the Dixie highway. Water supply was through 15,000 ft. of 2-in. pipe with a 7-h.p. C. H. & E. pump. Concrete equipment consisted of 1 Lakewood finishing machine, one 3-bag Koehring mixer and 1,000 ft. of Lakewood forms. There were seven 3-ton Autocar trucks. On the subgrade 2 rollers were used of Kelly-Springfield and Buffalo-Pitts manufacture. Miscellaneous equipment consisted of 12 teams, 1 Lee loader, 2 graders, 8 wheelers, one ¾-yd. Thew steam shovel and 3 small mixers.

Hart & Page had sections 18, 8 and G in De Kalb County. Water supply was through 16,000 ft. of 2-in. pipe with a 20-h.p. Fairbanks-Morse Company pump in conjunction with a pressure tank. Concrete equipment consisted of 1 Lakewood finishing machine, one 4-bag Koehring mixer and 1,800 ft. of Heltzel forms. There were two 1-cu.-yd. hoppers; 1 Erie steam locomotive crane of 13-ton capacity, with ½-yd. clam-shell bucket was used. One 15-h.p. International Harvester Company tractor was used and 6 motor trucks, 5 called "Government" trucks and 1 Packard. Thirteen wheelbarrows completed the equipment.

Cole & Fauber had the contract on sections K and L in McHenry County. Water supply was through 2,500 ft. of 1½-in. pipe in a 2½-h.p. Foos pump. The mixer was a Ransome of 1-bag capacity and 1,000 ft. of wood forms were used. The locomotive crane was of Keystone manufacture, steam-driven, 20-h.p., equipped with No. 3 clam-shell bucket. Four Nash-Quad trucks were used and 10 wheelbarrows.

Powers-Thompson Company had section A in Cook County. Water supply was through 1,400 ft. of 1½-in. pipe and 5,000 ft. of 2-in. pipe with 1 Deane pump and 1 Fairbanks-Morse Co. pump. Concrete equipment consisted of 1 Lakewood finishing machine, one 3-bag Koehring mixer and 900 ft. of Blaw forms. Four motor trucks from 2½ to 5-ton capacity were used, 2 being Republics and the other 2 Garfords. On the subgrade one 10-ton steam Huber roller was used. An Austin grader and 12 wheelbarrows completed the equipment.

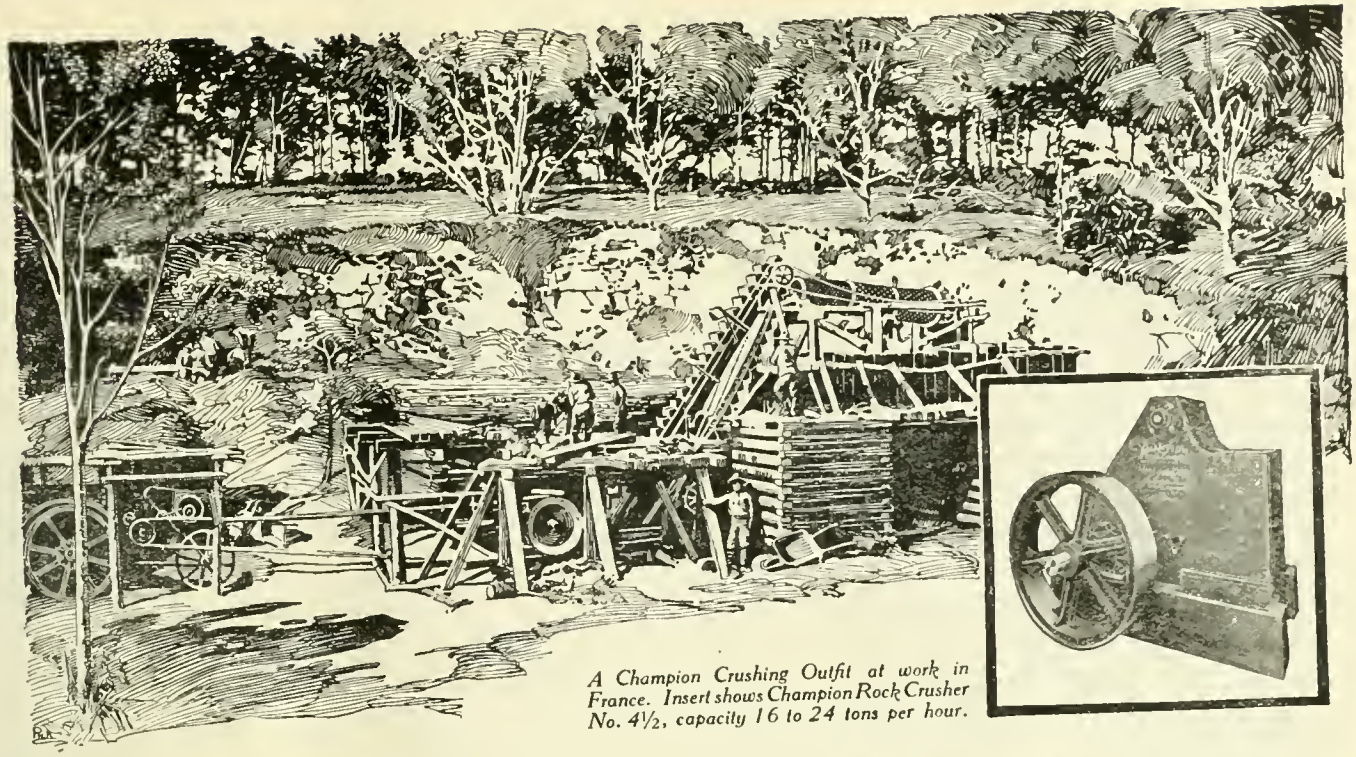
Powers-Thompson Company also had section G in Will County and obtained the water supply from a city plug through 11,000 ft. of 2-in. pipe. The mixer was a Koehring of 3-bag capacity and 2,000 feet of wood forms were used. On this job material was delivered along the road by an interurban railroad. Other equipment consisted of one 10-ton Huber steam roller, 6 material carts, a plow, a scarifier and a grader.

Calumet Construction Company had sections 1, 2 and G-29-a in Du Page County. Water supply was through 13,000 ft. of 2-in. pipe with one 7-ton h.p. Smith pump. Concrete equipment consisted of 1 Lakewood finishing machine, one 5-bag Austin mixer and 3,000 ft. of Heltzel forms. Storage piles were used, the sand pile containing 1,000 yds. the stone 1,600 yds. and cement 3,000 barrels. One Erie 20-h.p. steam locomotive crane of ¾ cu. yd. size was used. There were two 6-ton Koppel locomotives and 60 Koppel tramcars; also 100 1-yd. Koppel batch boxes filled by gravity and emptied by the crane on the mixer. The industrial track was of 24-in. gauge and 5 miles in length. Three Holt tractors were used and 3 motor trucks of Mack and Republic manufacture.

The Mellen-Stuart-Nelson Company had sections 50 and 51 in Cook County. Two pumps were used, one of Fairbanks-Morse manufacture and the other of Domestic Engr. Co. make. Concrete equipment consisted of 2 Lakewood finishing machines, two 4-bag Koehring mixers and 3,000 ft. of Blaw forms. Storage bins were provided of 120 cu. yds. capacity for sand and stone and 120 barrels of cement. Two locomotive cranes equipped with 1½-yd. clam-shell buckets were used, 1 a Mundy and the other a Flory. Six industrial locomotives were used, 2 Whitcombs and 4 Plymouths; also 60 Western tram-cars and 120 Western batch boxes of 32 cu. ft. capacity filled by gravity and emptied through bottom dump. The industrial track was 24-in. gauge and 4 miles long. One 75-h.p. Holt tractor was used on this job and 1 Carr subgrade machine; also two 10-ton Austin kerosene burning road rollers. Miscellaneous equipment consisted of 1 Austin scarifier, 3 Maywood scrapers, 6 wheel scrapers, 6 Fresnos, 2 Western plows and 2 No. 6 Western plows.

The Commonwealth Improvement Company had the contract on Higgins Road in Cook County. Water supply was through 15,000 ft. of 2-in. pipe with 1 Fairbanks-Morse, 1 Novo and 1 Domestic pump and 2 steel tanks. Concrete equipment consisted of 2 Lakewood finishing machines, 2 Marsh-Capron and 1 Austin mixer all of 4-bag capacity and Heltzel forms. One small mixer, 2 Barber-Greene wheelbarrow loaders, 1 Lidgerwood hoist and 1 No. 10 rock crusher with screens and bins, completed the equipment.

The Eclipse Construction Company were contractors on



A Champion Crushing Outfit at work in France. Insert shows Champion Rock Crusher No. 4½, capacity 16 to 24 tons per hour.

Getting the proper type of crushing outfit

Road builders and quarrymen know the advantages of a crushing outfit that meets their requirements exactly.

There is no need to compromise when buying Champion crushing, elevating and conveying equipment. There is a type for every purpose from the comparatively small, portable machines to the heaviest stationary plants.

Our staff of competent and experienced engineers are at your service at all times for the installation of this equipment.

An interesting booklet describing Champion crushing, elevating and conveying equipment will be sent on request.

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837 Bulletin Building **Philadelphia, Pa.**

The GOOD ROADS Machinery Co., Inc.

section 58 in Cook County. Water supply was through 10,000 ft. of 2-in. pipe with one 2½-h.p. Goulds pump and one 6-h.p. Barnes pump. Concrete equipment consisted of 1 Lakewood finishing machine, and one 4-bag M-C mixer and a small mixer for culverts; also 800 ft. of Blaw forms. On the subgrade one 12-ton gasoline Austin roller was used; 15 wheelbarrows completed the equipment.

Paschen Brothers had the contract for sections 11 and 15d in Lake County. Four Novo pumps were used on the water supply. Concrete equipment consisted of 1 Lakewood finishing machine and 3 M-C mixers and 2,500 ft. of Blaw forms. Two locomotive cranes equipped with a ¾-yd. clam shell bucket were used; also 3 Clark motor trucks. One 10-ton Austin steam road roller was used on the subgrade. Miscellaneous equipment consisted of 1 Austin scarifier, 2 conveyors and 6 dump cars.

SHORT CUT METHOD OF HANDLING MIXED AGGREGATE TO PAVING MIXER

Considerable interest has been manifested among road builders in the success of the Charles Connor Construction Co., of Denver, in the use of a short cut method of handling the mixed aggregate to feed the paving mixer.

The job under consideration entailed the laying of 26,000 sq. yds. of 6-in. standard reinforced pavement on the principal thoroughfare of Thermopolis, Wyo., probably the first paving work ever done in the Big Horn Valley.

Stationary bins were placed under a screening plant located at the gravel pit about three-fourths of a mile from the job, from which sand and pebbles were mechanically loaded through spouts into three 3½-ton and one 5-ton White trucks. These were fitted up with three and six compartments, respectively, each carrying 6 cu. ft. of sand and 9 cu. ft. of pebbles, the required amount of separated material for a three-sack batch. These aggregates were hauled direct to the mixer and dumped into

WHITE TRUCKS WITH COMPARTMENT BODIES DUMPING AGGREGATE DIRECT INTO LOADING SKIP OF SMITH PAVER.

the skip by releasing gates at the rear end of each double compartment and hinged at the top. The cement was added to the batch in the skip by hand.

This method of handling the aggregate insured a continuously uniform sized batch and with a considerable saving of both time and labor, the latter of which is a particularly important item at this time. The cost of the entire work of rehandling the material between the screening plant and mixer is estimated at $80 per day.

The paving was done with a Smith paver with a rotary distributing boom, the mixer having a capacity of 14 cu.

GRAVEL PIT SHOWING SCREENING PLANT OVER LOADING BINS.

ft. of mixed material per batch. This paver is over seven years of age and has been in practically continuous operation all of the time.

The surface of the pavement was finished by roller and belt and protected for 14 days by a covering of 2 ins. of moist earth. Standard ¼-in. premolded joints were placed every 30 ft.

So thoroughly do those interested approve of the results already secured from this initial paving project in Thermopolis that a petition has been successfully circulated for a new district involving six blocks and another for eight blocks.

READY BUILT OR LUMBER FRAMES FOR CULVERTS?

As an element in cutting the cost of concrete culverts, highway engineers and contractors will find interest in the following figures:

Based on the method employed by a highway engineer whose services are in much demand, it requires 29 ft. of 2-in. lumber to build the bracing for a 2 ft. by 2 ft. culvert, worth at present lumber prices about $3. Figuring that it takes three men two hours at 40 cts. per hour to put the lumber bracing for a culvert of this size in place, a labor cost of $2.40 is represented in putting the bracing in place. It takes one man probably two hours, or a labor cost of 80 cts., to knock out the lumber bracing when the culvert is finished. Thus the bracing for every culvert of this size represents a labor cost of $3.20.

For every different size of culvert new lumber must be bought and every set of lumber bracing requires replacing after being used on an average of five times.

A set of ready built steel culvert frames of the type here shown, can be set up in probably ten minutes, as they do not come apart and consequently require no putting together each time they are used. A simple pull collapses them and the lumber used with this frame not being nailed, it drops away undamaged when the frame is collapsed. Thus the culvert can be cleared in much less time than it takes to knock out lumber bracing and a large portion of the labor cost of lumber bracing is saved by this type of ready bracing.

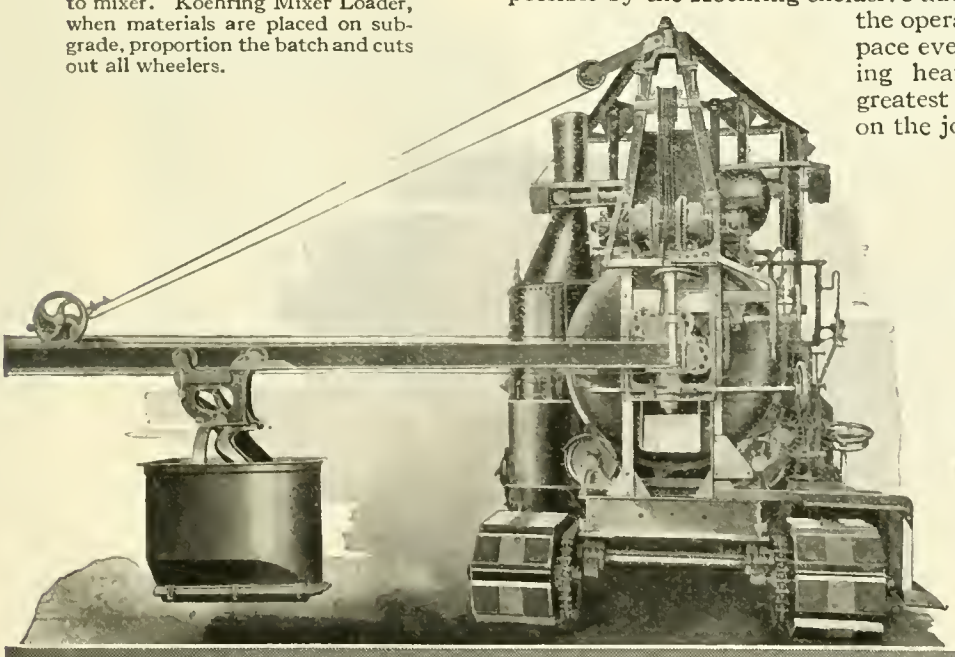
KOEHRING

Koehring loading derrick part of Koehring mixer equipment when batches are made up at central loading station and brought to mixer in batch boxes on industrial cars and trucks.

Long narrow design of Koehring Pavers gives extra room on subgrade to bring industrial car close to mixer. Koehring Mixer Loader, when materials are placed on subgrade, proportion the batch and cuts out all wheelers.

EXTRA yardage, every day, means extra profit—because the Koehring is the fastest paving unit—the mixer of liberal drum dimensions, fast loading and discharging, and with Koehring boom and bucket, the fastest distributor of any consistency of concrete.

It's the fastest paving **unit** because these fast operations are made possible by the Koehring exclusive automatic actions which enable the operator to keep up the high speed pace every minute of the day. Koehring heavy duty construction is the greatest profit-insurance you can put on the job.



KOEHRING SIZES

In cubic feet mixed concrete

Construction Mixers: 4, 7, 10, 14, 21, 28, Steam and Gasoline.

Paving Mixers: 10, 14, 21, 28. Boom and Bucket and spout distribution, caterpillar traction, loading derrick, steam and gasoline.

Write for Paver catalog.
Write for Mixer Loader catalog.

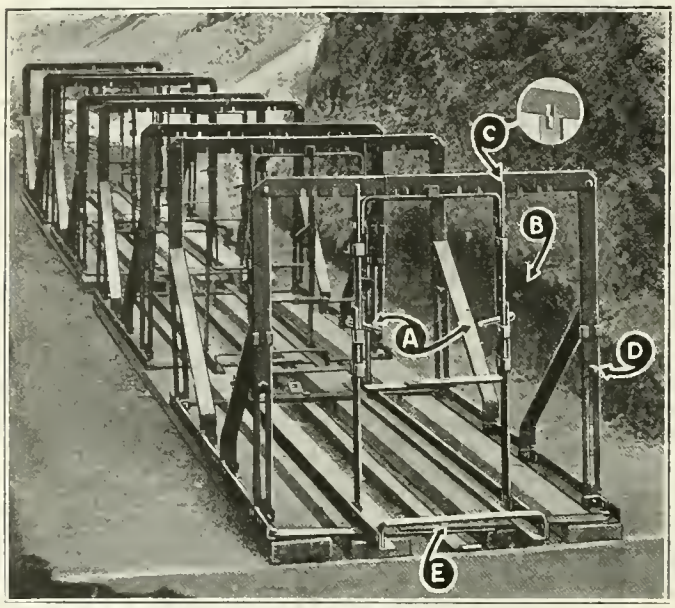
Koehring Machine Company

Milwaukee Wisconsin

Sales and service office in all principal cities.

Being adjustable both in height and width, a set of frames of this type will build a number of different sizes of culverts where lumber bracing, even where it can be torn out in good condition, can be used to build but one size culvert. The steel bracing is good for years of service where lumber bracing needs constant replacing, is another advantage in its favor.

From these figures the highway engineer and contractor can draw very accurate conclusions as to the relative

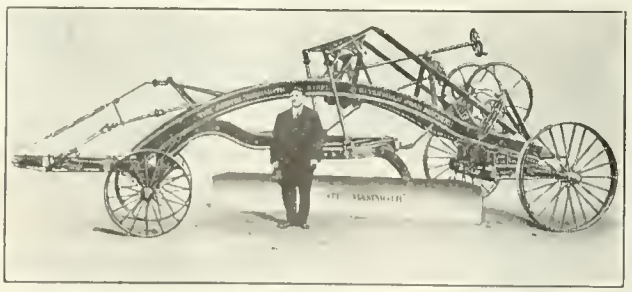


STORMS ONE-MAN COLLAPSIBLE CULVERT FRAMES.

time, labor and material costs of the two methods of culvert construction here discussed. The steel culvert frames used in this comparison are known as the Storms One-Man Collapsible Culvert Frames and are made by the Storms Mfg. Co., Crawfordsville, Ind.

GRADING EARTH ROADS IN NEBRASKA

The shortage of men, materials and machines, which may prevent many of the states from completing their road-building programs for 1920, is being felt in Nebraska as it is elsewhere. As a result the State Highway Department is concentrating considerable of its effort on the construction of earth roads, which later on may be



THE AUSTIN "MAMMOTH" STEEL REVERSIBLE ROAD GRADER AS OPERATED ON NEBRASKA HIGHWAYS.

converted into hard surface roads. This means that even though the mileage of concrete or other hard-surfaced roads built during 1920 may not be great, the State's road program will be going steadily forward. When the time comes for the construction of the hard surface much of the preliminary work will be out of the way.

As part of this program the State has just purchased 70 Mammoth graders from the Austin-Western Road Machinery Company of Chicago. These big machines, weighing 6,350 lbs. each and having 12-ft. blades, will all be delivered in time for the opening of the road construction season. They are being distributed among the majority of Nebraska's 90 counties and are accompanied by heavy tractors.

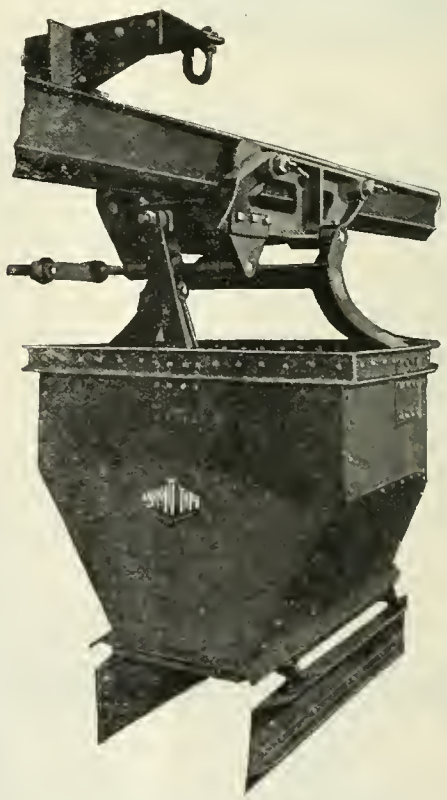
This buying of graders in wholesale lots is a usual practice and shows the progressiveness of the Nebraska Highway Department.

SMITH DISTRIBUTING BOOM AND BUCKET

An important advantage in the high drum design of paver is presented by the distributing boom-and-bucket on the Smith Simplex. Because of the height of the drum the boom has a clearance of 7 ft. making possible a deep, narrow bucket of ample capacity.

The deep bucket preserves the element of efficiency under all conditions. In discharging any mixture stiffer than a flowing concrete the aggregate has a tendency to pyramid but with this type of deep bucket the mixed material can pile up on a slope of 45 degrees and still the bucket will take the entire batch.

The bucket is equipped with an automatic opening and



SMITH DISTRIBUTING BOOM AND BUCKET.

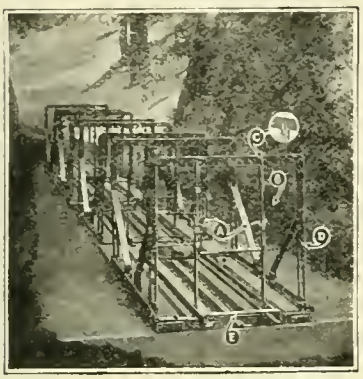
closing device. As it travels out on the I-beam boom, a finger wipes over the contact projections, placed 8 ins. apart, on the under side of the boom. The moment that the direction of the bucket is reversed the finger strikes the nearest contact, trips a toggle lock and opens the bot-

Contractors, Lumber Culvert Bracing Is Too Costly! Here's a Better Way

JOHN H. GORDON
ALBANY, N. Y.
October 7, 1919.

Storms Manufacturing Co.
Crawfordsville, Ind.

Gentlemen:
I am glad to write this letter recommending your Collapsible Forms for use in constructing culverts on State Highway work. They have given us satisfaction, are all that you claim, and have saved us time and money.
Very truly yours.
JOHN H. GORDON.



Here's a ready culvert bracing that's far better than cutting and building a lumber frame that you can use only a few times and for only one size culvert.

Highway engineers and contractors of a dozen states are building their culverts quicker and cheaper with these **adjustable** and **collapsible** culvert frames.

Think! It takes only about ten minutes (against two or three hours for lumber bracing) to put this

STORMS ONE-MAN
Collapsible Culvert Frame

in place and about the same time to clear the culvert when it is finished. Made of **steel,** adjustable in both height and width to different sizes of culverts. Positively guaranteed not to bulge, buckle or sag. Form lumber is **not nailed** and comes away undamaged when frame is collapsed by a simple pull on the tripping rod.

Why waste high-priced labor and lumber? Write **today** for exact cost data showing the saving of using Storms Frames. Ask for "Bulletin M. E. 1." It's free.

STORMS MFG. CO., CRAWFORDSVILLE, INDIANA

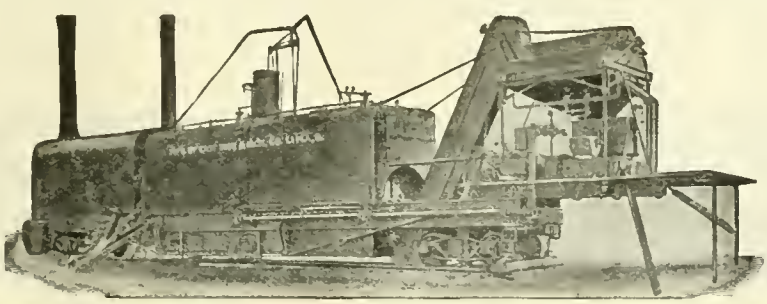
Storms Collapsible-Adjustable Culvert Frames.

Contractors, there is more money for you in the use of the Improved

MERRIMAN ASPHALT PLANT

Because it will handle more asphaltic material than any other plant, do it better, and at less cost.

Helps you to get the better Contracts



Write for capacities and full information

ALL MELTING IS DONE BY STEAM HEAT IN THE MERRIMAN PLANT

Good engineering calls for steam-melted asphalt because this process preserves all the natural oils in the mixture, and consequently produces a live, long-wearing topping, binder, or any other mixture that you might want to use. It is never of the lifeless character so often found when direct fire heat is used. Steam heat, you know, is used in the refining process because it gives the best results. The Merriman Plant carries out the principle.

Steam melting makes it impossible to burn or coke the asphalt. This means a tremendous saving of material—you know what loss burnt batches of asphalt mean.

It also eliminates the possibility of burning the kettle bottoms—another big saving of expense and loss of time when you're busy.

The car measures only 55 feet over all. It is easy to dismantle and set up. Has extra large mixer. Two large melting kettles—a day's run in each. Each unit can be operated separately.

The East Iron & Machine Co., Lima, Ohio, U.S.A.

tom doors. The bucket continues its travel back to the machine, a side roller upon it strikes a stationary guide on the boom, rides upward and closes the door.

These improvements are found on the Smith Simplex Paver, made by the T. L. Smith Co., 472 Old Colony Bldg., Chicago, Ill.

Contracts Awarded

ROADS AND STREETS

Ark., Blytheville—Good Roads Constr. Co., St. Louis, Mo., awarded contract by Miss. Co., Blytheville-Manila-Leachville Hwy. Commrs., Osceola, for construction of 50 miles of road, 17 ft. wide, 7-in. concrete rein., at $1,211,810.

Ark., Helena—Southern Roads Co., Nashville, Tenn., awarded contract to construct 34 miles road from Helena to Marvell; concrete with bitulithic surface, at $1,027,000.

Ark., Mountain Home—Miller Construction Co., Springfield, Mo., awarded contr. by Baxter Co. Road Impvt. Dist. No. 4, for surfacing 11 miles of road from Buffalo to Buford; gravel; 17,326 cu. yds. surfacing; bridges and culverts, $92,000.

Ark., Searcy—Burt Construction Co. awarded contract for constructing road from Searcy to the Prairie County line at Stineville, at $300,000.

Cal., Hanford—C. E. Blanchard, San Francisco, awarded contract for paving Harris, Elm, Myrtle, Katherine and S. Douty Sts. with 4-in. bitum. base and 1½-in. Warrenite surface, at $161,616.

Cal., Martinez—O'Brien Bros., City, awarded contract for paving with conc. 8.48 miles county hwy. betw. here and Hercules, at $178,892; Bates & Borland, Oakland Bank of Savings Bldg., Oakland, awarded contr. for constructing 7.3 miles of road in San Pablo Valley, at $103,784; Geo. W. Cushing, 420 Macdonald Ave., Richmond, awarded contract for constructing 3.2 miles of road betw. Avon and Bay Point, at $65,557.

Cal., Santa Rosa—W. A. Dontanville, Acampo, awarded contract for constr. of 5 miles of concrete hwy. on Sec. A, Petaluma-Sonoma Road, at 90c per cu. yd. for excavation and $105,000 for conc. pavement.

Colo., Pueblo—Strange-McGuire Co. awarded contract for paving North Side District, at $286,660.

Ct., Hartford—C. W. Blakeslee, New Haven, awarded contract for constr. of Hartford-New London Trunk Line, Fed. Aid Project No. 4, at total cost of $1,392,385.

Del., Dover—Field, Barker & Underwood, Philadelphia, awarded contract for 3.13 miles—Mt. Pleasant to Boyd's Corner, at $150,260; Fisher-Corosa Bros., Baltimore, contr. for Neaman's Creek road, 3.36 miles, at $224,336; also road from Hare's Cor. to the Causeway, 4.53 miles, $273,652.

Ga., Adel—Kries & Wardrep, Knoxville, Tenn., awarded contract to pave 8 miles of road on National Highway; Kentucky asph. or Finley method, 16 ft. wide, at $240,000.

Ga., Augusta—Ely Construction Co. and Lawrence Constr. Co. awarded contracts for constr. of 51,525 sq. yds. paving on Stovall, Winter, Wingfield, Heath, Reynolds and other streets; 7,700 lin. ft. granite or conc. curb; $190,000.

Ga., Savannah—Dixon Contracting Co. awarded contract to pave 40,000 sq. yds. streets; vibrolithic conc.; $578,000 available.

Idaho, Boise—Sims & Carlson, Spokane, will be awarded contr. for bldg. 8.4 miles of Clearwater Highway from Greer toward Fraser, if they will consent to alterations in the specfs. to bring cost within appropriation. Price will be about $150,000.

Ia., Garner—Empire Constr. Co., Des Moines, awarded contract for paving 90 blocks here, at $3.56 per sq. yd.—total cost $400,000.

Kans., Fort Scott—Maley & Keleher, Hutchinson, awarded contract for paving Fort Scott-Wichita Road, Bourbon Co., at $108,606.

Kans., Hutchinson—J. H. Shears & Son awarded contract for Avenue B paving, at $146,073.

Mich., Charlotte—F. P. Leonard & Co., Charlotte, awarded contract to build concrete road to extend from Ingham Co. line 6½ miles west to Grand Ledge, at $199,000.

Mich., Jackson—Brooks Constr. Co., Ft. Wayne, Ind., awarded contract for 11 miles sheet asph. paving, 22 miles conc. curb and gutter and 60,000 cu. ft. excav., at $650,000.

Mich., Muskegon—G. P. Scharl, Pontiac, awarded contract for constr. of 14 miles federal aid road in Muskegon county, at $520,365.

Minn., St. James—Johnson, Drake Pipe Co., Minneapolis, awarded contr. for 15 miles of paving at about $500,000.

Miss., Greenville—Brennan & Schevenell, Memphis, awarded contract for concrete street paving here, at $375,000.

Mo., Kansas City—Halpin-Dwyer Constr. Co. awarded contract to pave 2 4-10 miles of road, at $134,495.

Mont., Billings—State Hwy. Constr. Co. awarded contract for Proj. No. 53, Billings-Ballantine road—total 24 miles—at $149,137.

Mont., Helena—Clifton, Applegate & Toole, Spokane, awarded contract for 9½ miles highway from Anaconda to Deer Lodge county line, at $231,678.

Neb., Ord—Allied Contractors, Inc., 304 Bee Bldg., Omaha, awarded contract for paving; 5-in. conc. base with wearing surface of asph. concrete, at $149,079.

Nev., Carson City—Nevada Constr. Co., Hawthorne, awarded contr. for 9 1-3 miles rock cuts and road bldg. on west side of Walker Lake, at $168,889.

N. M., Santa Fe—Mishon, Millard & Teyssier, Pueblo, Colo., awarded contract for constructing 14.37 miles Fed. Aid Rd. Proj. 1-B, at $149,545.

N. C., Asheville—State Hwy. Comm., Raleigh, awarded contract to construct 5¼ miles hard-surfaced road, at $131,222, as follows: Grading, to Asheville Constr. Co., Asheville; surfacing, to H. C. McCraret Co., Knoxville, Tenn.

N. C., Brevard—State Hwy. Comn. let following contracts for constr. of 12 miles of gravel road, at $150,000; grading to Allport Alexander Co., Asheville; surfacing to Asheville Constr. Co., Asheville.

Okla., Marlow—Municipal Excavator Co., Okla. City, awarded contr. for 30,000 sq. yds. asph. conc. paving in business section, at $122,166.

Pa., Butler—Samuel Gamble Co., Carnegie, awarded contract for bldg. 30,180 ft. of road in Adams Twp. and Callery Boro, at $302,047; Burns Brothers, New Castle, awarded contr. for bldg. 18,778 linr. ft. of rd. in Fairview Twp., Karns City Boro, and Petrolia Boro, at $211,684.

Pa., Harrisburg—Dunleavy Brothers, Coatesville, contr. for 19,471 ft. road in Chester and Delaware Counties, extending thru Westtown, Willistown and Edgemont Twps., at $212,850.

Pa., Harrisburg—Following contracts aggregating more than $5,000,000, awarded by State Hwy. Commr. Sadler: Carbon County near Weatherly, 23,420 ft., to Sterling Constr. Co., Lodi, N. J., at $201,334; Delaware Co., Concord Twp., 14,892 ft., to Hayman & Goodman, Jersey City, at $181,737; Greene Co., Jefferson Boro vicinity, 13,811 ft., to Con-Oil Co., Pittsburgh, at $164,444; Northumberland Co. near Elysburg, 11,540 ft., to Fiss & Christian, Shamokin Dam, at $120,349.

Tex., Wichita Falls—Commissioners Wichita County let contract for paving 4.68 miles Hwy. 22, Fed. Aid Project 61, 18 ft. wide, involving 46,448 sq. yds. concrete and 4,358 cu. yds. grading, to Wichita County, care J. P. Jones, Co. Judge, at $182,726.

Va., Norfolk—R. P. Denby awarded contract to construct concrete rd. from Norfolk to Virginia Beach, at $369,000.

Wn., Chehalis—James & Hendricks, Che-

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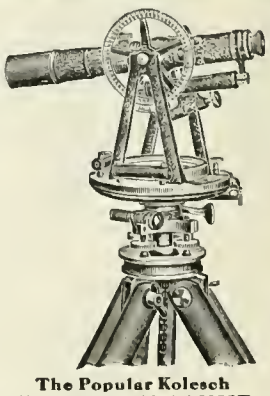


The Popular Kolesch "PIONEER" TRANSIT No. 7710.

EDITORIALS

TOWNSHIP FIRE PROTECTION

Recently the General Assembly of the state of Ohio passed a law authorizing township trustees to provide against fires and to provide and maintain fire apparatus and buildings for the use of volunteer fire companies.

Under this law the township trustees may establish all regulations necessary to guard against the occurrence of fires and to protect the property and lives of citizens against damages and accidents resulting from fires. When a volunteer fire company has been organized for service in the township, and of such character as to give assurance of permanency and efficiency, the trustees are empowered to purchase for the use of the fire companies such fire apparatus and appliances as may seem advisable. Trustees are also empowered to provide for the maintenance of fire equipment and to purchase, lease or construct and to maintain such buildings as may be necessary for housing the apparatus. They may also establish and maintain lines of fire alarm telegraph within the township.

The trustees are authorized to levy sufficient taxes to provide protection against fires and to provide and maintain fire apparatus and buildings for the use of the fire company. If 10 percent of the electors of the township petition the trustees requesting the submission of the question of issuing bonds in a sum not exceeding $20,000 for these purposes, the trustees are directed to submit the question to the voters at a special or the next general election.

If a majority of the votes cast favor the issuance of fire protection bonds, the bonds are to be issued and marketed in the usual way. The proceeds of the bonds are to be placed in the township treasury to the credit of the fire equipment fund.

The improvement in the class of farm buildings which has been so noticeable in recent years, clearly calls for improved fire protection in rural districts. The expensive farm house has long been a poor risk for the fire insurance company because of a lack of fire protection and fire fighting facilities, and insurance rates on such buildings have been correspondingly high. An improvement in the fire protection of such buildings will, eventually, lead to a reduction in insurance rates providing the highways of the township are passable at all times. We do not believe that any provision for the protection of rural buildings against fire will be adequate and fire insurance in such districts will not be reduced, unless buildings are located on highways over which modern fire apparatus can pass quickly at any time of the day and in any season of the year.

It has been observed that in many small cities and villages having modern motor fire apparatus the value of such apparatus is largely nullified to owners of homes in the outskirts of the city because of poor pavements or the lack of pavements. Oftentimes heavy motor fire apparatus has mired down and become temporarily useless in attempting to reach a fire in some building outside the paved portion of the city.

It must be apparent, therefore, that this movement for improved fire protection in townships must succeed or fail with the success or failure of local efforts to provide dependable highways. A stretch of even a few feet of mud road may be sufficient to defeat all of the fire protection efforts of the township. It is, therefore, of prime importance in this movement for better rural fire protection to provide highways capable of carrying modern motor fire apparatus at any time.

IN THE INTEREST OF STRAIGHT THINKING

It has been remarked that the progress of the American Association of Engineers in the stream of professional advancement was, for a time, "blocked by the ice of conservatism." It is true the ice has been broken and large blocks of it may now be seen moving noiselessly along with the current. Ten thousand new members in a year is an argument favoring the aims and accomplishments of the Association which cannot be ignored by those with open minds.

There is still some honest opposition to the Association among those who look upon it as a species of trade union. This view is compounded of loose thinking based on little information. As a plain matter of fact, but for the Association the salaried portion of the engineering profession would have become by now, in all probability, a trade union of the purest type.

Mr. L. K. Sherman, President of the United States Housing Corporation, and newly elected president of the Association, forcefully called attention to this fact in the inaugural address delivered at the annual convention in St. Louis on May 11. Speaking of the reaction from the spirit of self sacrifice, generosity and harmony which characterized the war period, he said:

"The restraint of the individual has been removed and the pent-up combative spirit of selfishness, greed and intolerance has broken into the flames of radicalism. Almost every separate trade, industry, business or profession today is organized for its material ends. . . . Radical thought has not been confined to the trades. We have seen examples of scores of the most

highly trained and specialized men carried off their feet in one evening's meeting to accept membership and dictation in the closest form of trade unionism. . . . The Association has been the means of preventing the exodus of thousands into the alternative of trade unionism. The A. A. E. is conserving the unity and integrity of the profession. For this the thanks and respect of those most honored members of the old school are due the American Association of Engineers."

Selah! Or, as we moderns say: Stop and think!

AN ENGINEER IN POLITICS

At last we have what engineers have wanted for many years: an engineer candidate for a presidential nomination. Herbert Hoover may fairly be called the engineer's choice for the presidency, if we are to judge from endorsements of his candidacy by engineering societies and by engineer's branches of political clubs.

We have received an interesting letter from the Engineer's Branch of the Hoover Republican Club of Illinois which states that the engineers of Illinois are organizing to show the Republican nomination convention that they are for Hoover for president.

The Hoover Engineers' Committee enumerates several reasons why they favor him, including: His great technical and successful business career; his wonderful gift for organization, as shown in Belgian Relief and Food Administration Work; his intimate knowledge of world-wide conditions and men; his ability to get their best efforts from his associates, and his training, education and experience as an administrator of the highest type.

If Mr. Hoover is indeed the choice of engineers for the presidency we wish him well. Undoubtedly he would make a good president and, early in his administration at least, he should be popular. Quite likely after this honeymoon period various individuals would begin finding fault with him in the regulation manner. However, as stated, if he wants the place and engineers want him to have it, we are for him.

Is this a partisan, political editorial? Not at all. How could one be accused of partisanship in discussing the candidacy of Mr. Hoover? This is at least a bipartisan discussion, if it is not nonpartisan, for isn't he a liberal competing for the nomination by the conservative party? It may happen, though we hope our fears are unfounded, that in pressing toward the mark with his eyes fixed on the presidency as his goal, he may stub his toe on the first hurdle, namely, the nomination. It is just possible he might have done better, entertaining liberal views, had he sought the nomination at the hands of the liberal party. We fear that some conservative old Isaac at the Republican convention may remark that while the hands pass acceptably for those of Esau the voice is unmistakably that of Jacob.

A LIVING WAGE FOR THE ENGINEERING EDUCATOR

Teachers in engineering colleges are among the "forgotten men" with respect to compensation in money. Many of them are feeling the merciless pinch of poverty and unless soon relieved will abandon teaching for some other form of employment paying a living wage. It would be easy, from the data in hand, to draw a picture of the financial distress of these worthy men, but we need do no more than remind the reader that the salaries of engineering teachers which made close figuring necessary five years ago are still in effect in many, if not most, cases, and are insufficient to maintain either health or happiness from day to day, to say nothing of saving for old age. Something must be done, and done quickly, to provide better pay for engineering educators or the cause of engineering education will suffer a blow from which it will not soon recover. We are nearing the end of the school year, and unless funds are provided, in some manner, for the adequate payment of engineering teachers next year, we predict that a very great many of these men will terminate their teaching work with the present collegiate year.

This is a matter for all of us to face squarely and at once. First of all we must disabuse our minds of the foolish school-boy prejudice against teachers. In the present scheme of living the teacher performs an indispensable service and we must recognize that fact. We simply must have teachers and we should demand good ones. And the good ones should demand adequate pay, so that they can feed and clothe their families properly, safeguard health, keep their life insurance policies in effect, and provide for the scale of living essential to the happiness of people of culture and refinement.

These men have continued teaching thus far because of their love for the work. Surely engineers can appreciate this spirit for it has kept them in engineering when fortune beckoned elsewhere. But conditions have become so acute that the teachers cannot go on much longer without relief. They will be left no choice but to resign and accept any one of the offers frequently made all successful teachers by commercial organizations.

We hope the engineering colleges can secure more funds but if they can't they must live on what they have. It should be considered a disgrace to any college to spend another dollar for new buildings or new equipment until the teachers have been given salaries on which they can live. Colleges must shake off the "boom town" fever and get down to the bedrock of justice to the teacher. Without good teachers the finest university plant will be but a mockery of the cause of education. Let us have done with the physical expansion of the university until it has been made sound at heart.

Construction and Inspection Methods Employed in Building the County Brick Pavement Connecting Waterloo and Cedar Falls, Iowa

By E. A. Zack, Resident Engineer, Iowa State Highway Commission, Ames, Iowa, and C. M. Fisher, County Engineer, Black Hawk County, Waterloo, Iowa.

Black Hawk county's first paving project is a trifle over four miles in length and connects the cities of Waterloo and Cedar Falls. Waterloo has a population of about 35,000 and Cedar Falls of 6,000. Both towns have several manufacturing enterprises and wholesale houses from which originate considerable truck traffic from town to town. There are at least three regular truck routes, and several tourist routes, namely, the Grant Highway, Red Ball Route and Iowa Parks Highway, which follow this road. In addition, most of the adjacent land is included in the incorporated towns of Cedar Heights and Castle Hill, prosperous residential suburbs. From all these sources very heavy traffic, both commercial and pleasure, use the road, necessitating a substantial type of pavement.

Bituminous-Filled Brick Pavement on Concrete Base

The contract for the work was awarded June 20, 1919, to the Moore-Young Construction Company of Waterloo, and construction began early in June. The contract price was 65 cts. per cu. yd. for grading, and $3.75 per sq. yd. for a bituminous-filled brick pavement on a concrete base. The total cost will be about $170,000, or $42,000 per mile; $69,000 of this is to be paid from the primary road fund, the balance to be borne equally by the county road cash fund and by donations. This project was started before the present road law went into effect so that no special assessments can be levied.

The pavement is 18 ft. wide with a uniform thickness of 8½ ins. It has a 2-in. crown and an equally crowned subgrade. The base is 5 ins. thick, of concrete proportioned 1 to 3 to 5. A ½-in. sand-cement cushion, protioned 1 to 4, is used and 3-in. vitrified brick without lugs, filled with bituminous filler, completes the pavement.

When the work was advertised I had visions of the use of considerable industrial equipment. Old methods, however, prevailed. The situation of the road with respect to railway sidings probably made it inadvisable to invest in more machinery. The Waterloo, Cedar Falls and Northern interurban tracks lie within a few hundred feet of the road for almost its entire length. Materials were brought in over this line and unloaded on three existing sidings. Aggregates were shovelled by hand directly from the cars to wagons and hauled to the subgrade. The mixer was loaded by the use of wheelbarrows.

Construction Methods and Equipment.

All water was obtained from city mains which extend sufficient at all times to maintain the supply, and no for a considerable distance along the road. Pressure was pumping was required.

Rough grading was handled with an elevating grader drawn by a steam tractor. Bottom dump wagons were used. Both Fordson and Dart tractors were tried with the wagons, but teams proved more successful. Fine grading was completed with pick and shovel. Fills were rolled in 6-in. layers with a 1-ton tandem roller.

Concrete was mixed in a 2-sack batch Foote mixer with discharge chute. Several kinds of aggregates went into the base. About two-thirds of the work contains a 50-50 gravel mix obtained from Mason City. This material required about 5 sacks of cement per cu. yd. of gravel. The balance of the base is composed of gravel obtained from different pits in the county, and limestone from the Glory quarry, proportioned 1 to 4 to 4. This gravel contained about 18 per cent. of material retained on a ¼-in. screen, which accounts for the change in proportions.

After the concrete was placed and well spaded, it was struck off with a wooden template, cut to crown, and finished with a long-handled wooden float. As smooth a surface and as dense concrete was secured as on many concrete pavements. Curing was done by ponding, earthen dikes being thrown across the pavement at intervals of 50 to 75 ft. and the concrete surface was covered with water.

Curbing

A curb 6 ins. wide and 3½ ins. deep was built integral with the base. It was constructed in the following manner: After the base was poured, a 2 by 4 was placed on the concrete for the inside curb form. It was held away from the side form by steel spreaders and held in place by U-shaped irons passing over both side form and inside curb form. A batch of mortar proportioned 1 to 2 was then run through the mixer and deposited with a shovel in the curb form. This was well spaded and troweled to a smooth finish. Metal plates ⅛-in. thick were used to divide the curb into sections about 10 ft. long.

The Cushion

After the base was thoroughly cured, the cement-sand cushion was placed. The sand was hauled and dumped and mixed dry with the cement in a small drum mixer. This was distributed with wheelbarrows, spread with shovels to a thickness of about ¾-in. and struck off to a thickness of ½-in. with a wooden template drawn by horses.

Applying the Filler

The brick, which had been piled along the shoulders, were then placed and inspected. Culls were replaced with good brick and the surface swept clean and rolled. A 4 to 6-ton tandem roller was called for in the specifications, but it was found that many of the brick were broken by the roller, and accordingly a 3-ton, horse-drawn roller was substituted. After being rolled, the surface was again swept clean and sprinkled. It was neces-

sary to wait until the brick became thoroughly dry before the bituminous filler could be applied, otherwise the filler failed to adhere to the brick. The bitumen was heated in a large kettle to 450 degrees F., distributed in pails and squeegeed into the joints. A ⅛-in. layer of sand was then sprinkled over the surface, forming a bitumen and sand surface over the brick from 1/16-in. to ⅛-in. thick.

Procedure in Cold Weather.

Work continued until after cold weather began. In fact, some brick were laid only a few days before Christmas. In cold weather it was found necessary to sprinkle the cement-sand cushion before laying the brick in order to keep the cushion from freezing. It also became necessary, at times, to heat the brick before applying the asphalt filler. For this purpose a surface heater was used. This consisted of an iron cover about 5-ft. square, the edges fitting down closely over the pavement surface under which gasoline flames burned. The results were satisfactory when the brick were covered only by a light frost or a very light snow, but when the joints were filled with ice, it could not be melted without injuring the brick.

This road has been visited by a great number of road officials from this and other states, who have been unanimous in pronouncing it one of the very best pavements they had ever seen.

Inspection

Inspection was in charge of Resident Engineer E. A. Zack of the Highway Commission. At the start, he was given an instrument man and was expected to secure such additional help as needed from non-technical local men. This plan proved satisfactory for rodmen and helpers, but after a short trial, non-technical inspectors were replaced by those who had received special training. The party was supplied with a car, transit, gravel screens and such other tools and materials as were needed. In addition, the work was looked over every 10 days or 2 weeks by a representative of the U. S. Office of Public Roads, and by the Construction Engineer and the Division Engineer of the State Highway Commission.

Slope stakes and finish stakes for grading, tile stakes and curb stakes were set by the inspectors. Curb stakes were set 1 ft. outside the edge of the pavement and blue-topped or marked to even tenths of a foot. Stakes were also set and quantities figured for borrow pits.

One man was stationed at the mixer watching proportions, consistency, subgrade, alignment of forms, finishing and curing, and checking up the amount of cement used. Cement was then measured in sack and aggregates in wheelbarrows.

A second inspector looked after the brick work, directing the mixing and placing of the cement-sand cushion, placing of the brick, sprinkling, cleaning and pouring of the asphalt filler.

Ten brick from every third or fourth car as received and a composite sample from a half dozen sacks in each car of cement were forwarded to Ames for complete tests by the State Highway Commission. Samples of gravel from several pits were also sent to Ames for analysis. So much time elapsed before reports were received on many of these tests that the materials had already been incorporated in the pavement. For example, when the reports were received a sample of gravel was sent to Ames about June 1. This gravel was some that the owner hoped could be used, and he was anxious to have it tested so that if it proved satisfactory the contractors could figure on using it. The report of the test came the latter part of July, about a month late. I understand that the commission has made arrangements to remedy this situation, and during the present year will provide testing apparatus either on the work or in the district offices to relieve any anxiety as to the quality of materials to be used. I will say that so far as I know none of the tests showed very serious defects in any of the materials.

Monthly Estimates and Reports.

The resident engineer made up monthly estimates of the work completed and materials delivered, which were paid for by the county or state. These claims are subject to considerable red tape before the contractor gets his money. They are sworn to by the contractor, checked and approved by the district engineer, allowed by the county board, checked and approved by the Highway Commission and finally checked by the Auditor of the State and warrants drawn.

An extensive system of reports was prepared by the resident engineer. There was first a daily report showing the time distribution on all parts of the work, the amount and location of the work. From this a weekly progress report was made up and forwarded to the commission. There were also various reports on materials received, samples taken for tests, and other items. Complete data were also filed on engineering and inspection work and costs.

The work was closely, and I believe, fairly inspected. Good materials properly proportioned and first-class workmanship were insisted upon. Through the combined efforts of the contractor and the engineers, a first-class pavement was built. We are proud of it, and invite engineers to come to Waterloo and see it.

The foregoing paper by Messrs. Zack and Fischer was presented before the recent annual meeting of The Iowa Engineering Society.

THE MODERN HIGHWAY SYSTEM OF BUNCOMBE COUNTY, NORTH CAROLINA

By N. Buckner, Secretary of Board of Trade, Asheville, N. C.

Buncombe County, North Carolina, of which the widely-known city of Asheville is the county seat, is one of the best paved counties in the South. It is one of the chief centers of the movement for hard surfaced highways which has already been productive of much good throughout the South. In round numbers Buncombe County has $800,000 worth of paved roads, with 31 miles now under construction. This mileage will be completed in the spring and summer of 1920 and will make a total of 163 miles, paved at a cost of $2,000,000, in addition to $554,000 worth of bridges, most of which are concrete and steel.

In addition to the improved roads in Buncombe County, and to those already built in western North Carolina, the State Highway Commission now has projected 264 miles of hard roads, every mile of which leads, directly or indirectly, to the city of Asheville. A sum of nearly $2,000,000 is now available for highway improvement

work in the western district of the State which includes 22 counties. This sum includes the federal aid, state aid and funds appropriated by counties to augment state and federal aid. This amount will be spent on the following highways: Central, Asheville-Charlotte, Asheville-Brevard, Asheville-Murphy-Atlanta, Asheville-Burnsville,

FIG. 1. ASHEVILLE-WILMINGTON-CHARLOTTE HIGHWAY, 18 FEET WIDE, CONSTRUCTED OF TEXACO ASPHALTIC CONCRETE OVER WORN-OUT MACADAM BASE.

Spruce Pine, East Tennessee and Southwest Virginia, Boone Trail and Blowing Rock highways; all of which lead to the eastern branch of the Dixie Highway system from Mackinaw south through the great grain and cotton belts, and the wonderful mountain section of Kentucky, East Tennessee and the famous "Land of the Sky" in western North Carolina, which is eastern America's climax in altitude and scenic grandeur.

Paving on Dixie Highway

The Dixie Highway crosses the Tennessee state line seven miles west of Hot Springs, North Carolina, and is paved across the county, a distance of 28.3 miles, with the exception of 2.3 miles which are heavily gravelled on the western side of the county. Approximately 14 miles of this is asphalt macadam, 2 miles of brick and 10 miles of concrete. The 10-mile stretch of concrete south of Asheville to the Henderson county line was completed in May, 1919, the work continuing through the period of the war. The city of Hot Springs, previously mentioned, was used as a camp for about 3,000 interned Germans during the war.

The secretary of the Asheville Board of Trade, and T. W. Howerton, County Road Engineer, made a special trip to Washington and showed, to the satisfaction of the War Industries Committee in charge of the distribution of Portland Cement, that the completion of this 10-mile concrete road was really a war necessity, in that it connected Asheville, where were located U. S. Army Hospitals for wounded and gassed soldiers, and Camps Green, Wadsworth, and Jackson, 60, 70 and 180 miles distant, and on direct lines to the camps at Augusta and Atlanta.

This concrete road is 20 ft. wide, 7 ins. thick in the center, tapering to 5 ins. at each side. The cost of constructing this road, which before the war started was around $18,000 a mile, had increased when the road was finished in May, 1919, to around $25,000 per mile.

In addition to 150 miles of hard surface roads in Buncombe County, there is approximately 800 miles of well-graded, top soil surface roads good for automobile traffic during eight to ten months of the year.

Some detailed information as to the cost of various kinds of roads follows: 19 miles of concrete cost $406,464.26; 26.7 miles of asphalt over old macadam road cost $339,999; 16 miles of waterbound macadam cost $133,000; and 70 miles of sand clay road cost $183,000. The cost items were kept for these particular lengths of road, part at pre-war prices and part at war prices.

Approximately $150,000 worth of reinforced concrete bridges have been built over the French Broad river above and below the city of Asheville to replace steel structures washed away by the unprecedented high water of July, 1916. The larger bridges constructed across the French Broad river mentioned in the following table, were all constructed since "the flood" except the West Asheville concrete bridge:

	Length in Feet	Cost
Craggy, Overhead Bridge (concrete)	650	$59,000
Pearson's Bridge (concrete)	400	19,000
Smith's Bridge (concrete)	500	33,000
Long Shoals Bridge (concrete)	250	10,000
West Asheville Bridge (concrete)	740	71,000
Alexander Steel Bridge	350	14,000

FIG. 2. ASHEVILLE-WILMINGTON-CHARLOTTE HIGHWAY AT MILE HOLE GAP, NORTH CAROLINA.
This is also an Asphaltic Concrete Highway over old Macadam.

In addition to these large bridges, built at pre-war prices, and worth twice as much now, quite a number of smaller concrete and steel bridges and concrete culverts have been built on the main arteries of travel in Buncombe County. The total cost of all bridges in the county is $554,402 with the cost of steel bridges totalling $54,620, and wooden bridges including those with I-beams $24,250.

County Has Commission Form of Government

Buncombe County has commission form of government with three commissioners giving full time to the handling of the affairs of the County. The present Board of County Commissioners consists of: B. A. Patton, Chairman and Commissioner of Finance; Otto Israel, Commis-

sioner of Public Highways, and G. F. Stradley, Commissioner of Public Institutions.

Convict Labor Employed

Convicts from the superior court of the county and the Asheville Police Court are used for work on the public roads and are handled in well equipped, permanently located sanitary camps, and are taken to work in a big White truck every morning and returned to the camp in the afternoon. The camps are all lighted with electricity and have every sanitary convenience. The men are given an abundance of wholesome food. The county authorities feed the garbage to hogs at each camp. One or two

FIG. 3. CENTRAL HIGHWAY BETWEEN ASHEVILLE AND MOORHEAD CITY, NORTH CAROLINA.
Built of Texaco Asphaltic Concrete over old Macadam.

cows are kept to provide cream for coffee and milk for cooking purposes. This method has proven quite economical; it improves food qualities, and adds a touch of farm life for the unfortunate men in the camp.

County Owns Quarries and Road Machinery

The county owns three quarries and a full complement of road machinery and equipment. The quarries are located on a spur track of the Southern Railway, and the crushed stone can be loaded for shipment to the various points in the county on the railroad. Cars of crushed stone are occasionally sold in commercial channels at the usual profit. A recent audit shows value of road machinery at $37,500, auto trucks and teams at $14,750, and quarries and land at $7,500.

THE NEW BUILDING ZONE ORDINANCE OF PORTLAND, OREGON

By Charles H. Cheney, Consultant, City Planning Commission, City Hall, Portland, Ore.

A comprehensive building zone ordinance has been adopted by the city of Portland, Ore. (population estimated at 320,000), which it is believed will do much to foster industry, stimulate home ownership and contented home conditions for industrial workers, as well as make the city a more comfortable, orderly and convenient place for all who live and work here. This ordinance was the result of some 18 months of careful study and more than 150 meetings and conferences by the City Planning Commission and the neighborhoods and property owners affected in all parts of Portland.

Use of Data Maps

Complete use of property maps and other data maps were prepared, showing the existing conditions and tendencies of growth of the city. These were carefully discussed by representative property owners' committees in each neighborhood who, with the aid of the City Plan Commission, evolved a preliminary zoning plan, which was ratified at a neighborhood meeting, to which all property-owners of the district were invited. These neighborhood plans were later pieced together to make up the general preliminary zoning plan for the city. After public hearings during a number of months, before both the City Planning Commission and the City Council, the ordinance was finally adopted in its present form on March 17, 1920. It will be subject to a vote of the people at the general election next November.

Benefits Expected

In its final report to the City Council the City Planning Commission said that it was to be expected that this ordinance would benefit the city as follows:

1. Stabilize and protect property values and investments.
2. Protect the maintenance of the home and of home neighborhoods.
3. Offer a safe district in which industries may be located without fear of protest and with every facility to do business.
4. Prevent undue congestion of population.
5. Insure better sanitary conditions.
6. Simplify the problem of street traffic regulations.
7. Make possible a sensible and more practical street paving program for the future.
8. Render possible great economies in the paving of city streets through a decrease in the width of roadways, where sizes and number of buildings are limited.
9. Insure the permanence of character of districts when once established, permitting and encouraging orderly enlargement of business centers and industrial zones while preventing the scattering and intrusion of any inappropriate and destructive uses of buildings which deteriorate and decrease property values; and, finally,
10. Make Portland a more orderly, convenient and attractive place in which to live and work.

The new Portland zone ordinance combines the principal protective features of the Alameda, Los Angeles, St. Louis and New York zone ordinances. It applies to new building permits only, existing buildings and uses not being affected, even though they fall outside the respective zones proper for them.

The Use of Property Regulations

It was found necessary to establish eight kinds of classes of use districts. These comprise two kinds of residence classes—Class I, for single family dwelling primarily, and Class II, for any kind of dwellings, including flats, apartments and hotels; two kinds of business classes—Class III, for ordinary retail stores, offices and dwellings, and Class V, for all kinds of retail, wholesale and other business, except industries, including dwellings; two kinds of industrial districts, Class VII, for all ordinary non-offensive industries and business, and Class VIII, for the odor and smoke-producing plants; and two

special classes of use districts—Class IV for public and semi-public buildings, parks, etc., and Class VI for hospitals, charitable homes, etc.

At present it was decided that there should be no Class VIII districts within the city limits, a large industrial area for stock yards and similar industries already being well established outside the city limits to the north, where prevailing winds will carry away offensive odors and smoke. There are, therefore, really only seven classes of use districts established at this time, which may be more particularly described as follows:

Classes of Use Districts

Class I resident districts will permit new single family dwellings, churches or schools only. Approximately 85 per cent. of all buildings in Portland today are single family dwellings, and the City Council has now set aside about two-thirds in area of the whole city for Class I districts to protect homes at the request of property-owners.

Class II residence districts, permitting any kind of new dwelling, flat, hotel or apartments, were established around the central core of the city and in numerous small districts through the outlying sections. Buildings of this type actually cover today an aggregate of about 250 blocks (200 ft. square) throughout the city. The zone ordinance establishes 1,250 blocks in Class II, beside permitting this type of buildings in over 800 more blocks of business districts of Class III and Class V. It is estimated that this allows apartment house space enough to take care of Portland's needs in this type of buildings until the population exceeds a million and a half.

Class III business districts, for all ordinary stores, trades and professions, including any kind of dwellings of Classes I and II, were established to cover the downtown retail center and a number of retail centers which desired to keep out the public garage and other businesses which interfere with the best retail store development.

Class V business districts, permitting any kind of new retail or wholesale business, warehouses, public garages, dyeing and cleaning establishments, undertaking parlors, etc., were established surrounding the downtown retail center, and at practically all existing local business centers at cross roads, about every half-mile conveniently located, through the outlying residence districts, and on practically all main traffic arteries.

Class IV districts, for public and semi-public buildings, schools, churches, playgrounds, parks, airplane landing fields, libraries, fire houses, greenhouses, etc., were established to cover every existing property of such use in the city.

Class VI districts, for hospitals, sanitariums, clinics, day nurseries, homes for the aged or children, and other charitable institutions, were established to cover existing institutions of this type that the surrounding neighborhoods would agree should be permanently located there. In a few cases where good home neighborhoods had been invaded by such institutions, the property-owners vigorously protested against making them permanent, and these will either have to seek a new location or convince their neighborhoods before they can be enlarged.

Class VII industrial districts, for all ordinary, not obnoxious, industries, warehouses and factories, including any business use, but excluding new residences of any kind, were established to include approximately 6,000 acres within the city limits, in which practically all such existing properties are today located.

No new residences are to be permitted in the industrial districts, as in Alameda, Newark, etc. The small residence owner fights improvements that industries must have in the way of wide, heavy-hauling pavements, extra large sewers, unlimited spur tracks, closing of streets, etc. Plants desiring housing sites for employes adjoinings their works can have that portion of their property reclassified in one of the residence zones.

Limits on Heights of Buildings Established

To protect the city from overcrowding at a few points and from scattered overhigh structures, limits on the height of new buildings are established in the ordinance, with appropriate regulations to meet the needs of the different use districts. The following height districts were established:

The 2½-story height districts, limiting new buildings to a maximum of two stories and finished attic, not to exceed 38 ft., were established to cover the outlying single family residence districts of Class I. It was found that 97.5 per cent. of all existing buildings in the city are of 2½ stories or under, and it was thought advisable to maintain this character of homes for the best interest of both home owners and the city.

The 3-story height districts, limiting new buildings to 3 stories or not more than 42 ft. in height, were created to cover nearly all the small outlying business and apartment house districts.

The 4-story height districts, including new buildings to 4 stories or not more than 60 ft. in height, were made to cover the apartment house and business districts just away from the center of the city.

The 6-story height districts, limiting new buildings to 6 stories or not more than 85 ft. in height, were established to cover the closer-in apartment and business centers, except the central downtown district.

The 8-story height districts were established limiting new buildings to 8 stories or 105 ft. in height in the industrial zones and in the wholesale districts in the center of the city.

The 10-story height districts, with a limit of 130 ft. in height, were established for the central downtown retail district only. A few buildings of 14 and 15 stories already existed in this district and the testimony of the assessor and owners of property was that they were not profitable, aside from the fact that they cast a shadow cutting off light and air from their neighbors. These downtown regulations were the result of many months' study by a representative committee appointed by the Realty Board and Building Owners' and Managers' Association.

Towers, gables, spires, grain elevators, gas or water tanks can exceed the height limit provided they set back 1 ft. for each additional foot of height above the height limit and do not cover more than 2,500 sq. ft. on the base area.

Area Requirements

In business and industrial districts rear yards are required, but only where windows necessary for light and air are opened at the back of the building. Portland already has a housing code pretty well protecting dwellings, apartments and hotels. In the Class I single family dwell-

ing districts property owners asked to have their neighborhood kept as open as at present and accordingly home area regulations were established to cover all Class I districts, requiring new dwellings to cover not more than 40 per cent. in area of the lot at grade nor more than 30 per cent. in area of the lot above a level above 16 ft. above grade. It was found that practically all the homes in these districts at present cover only from 20 to 25 per cent. of the lot and that therefore this regulation would not prove onerous. It is similar to the requirement of the Class E area districts in the New York City zone ordinance.

Flexibility and Method of Amendment

The importance of a reasonably simple method of amendment was much emphasized in preliminary discussions on the zoning ordinance and as finally passed it is arranged that any property owner, upon filing a list of all owners within 200 ft. of the property desired to be reclassified, can set in motion the machinery for bringing about a change. The matter is then automatically referred to the City Planning Commission for report, and upon receipt of this report the auditor shall within not less than 12 days set a hearing before the City Council, notifying all property owners within 200 ft. The action of the council is then final, and the whole proceeding can be accomplished in a week's time if special occasion requires it. It was realized that no zone ordinance can be perfect, and any such instrument must be a living and growing thing if the city is to progress. While the tendencies of city growth under zoning will undoubtedly be to maintain the business and industrial centers as established, enlargement from time to time of their boundaries and of the apartment house, or Class II, zone is to be expected to keep up with the normal increase of the city.

Importance of Zoning at This Time.

The importance of the adoption of a zoning plan by Portland is evident at this time, as the city is undoubtedly entering upon an era of great expansion, in addition to having to catch up for five years of lack of building during the war period. It was urgent to have some sound basis for settling where the industrial districts are to be and where the facilities for them can be concentrated. This the zone ordinance will do, as well as establish safe, protected home neighborhoods near industries for the housing of industrial workers.

Bidding for New Industries

Competition has become an important factor between Pacific coast cities hoping to secure new industries. It is well known that some dozen or fifteen of America's largest industries are getting ready to locate coast branches. Alameda, Berkeley and other cities have already established industrial zones, where greater facilities and privileges are being concentrated than obtainable elsewhere. Seattle, Tacoma, Spokane and San Francisco all have zoning commissions at work, each trying to make ready to attract these great payrolls. Portland seems so far to be ahead of them, if certain reactionary forces within the city do not prevail.

The city's industrial commission, or Committee of Fifteen, as it is called, has brought forward a most important plan for the improvement of the harbor at a cost of $10,000,000, bonds for which will undoubtedly be voted in November.

The Building Trades Council and most of the lending institutions of the city urged the passage of the zone ordinance as an encouragement to building. They pointed out that many owners were now afraid to build for fear of what might locate next to them and prove a detriment. Zoning will give a sense of security and a solid foundation for investments to poor men and rich men alike, not heretofore possible with unregulated growth.

Evidence of the Experience of Other Cities with Zoning

During the discussions on zoning before the Portland City Council question was raised as to exact evidence on the experience of cities that had already adopted zone ordinances. It is interesting that we were able to discover no city that had abandoned zoning after once trying it out. Nearly every zoned city has found it necessary to amend and readjust boundaries from time to time, but this we take as an evidence of progress.

Mayor George L. Baker wired the mayors and realty boards of a number of the principal cities of the country, and the following replies are of value as current opinion only:

Oakland, Cal.—"Oakland has had zoning ordinance in effect since April, 1915. Results satisfactory to everyone."

Los Angeles, Cal.—"We have zone ordinance protecting business and homes, working satisfactorily."

New York City.—"New York zoning ordinance enacted July, 1916. It has met universal approval. It has protected business and residence property. In some residence sections decline has been stopped and important improvements made. Other residence sections have been much enhanced in value. The height, area and use provisions have all been of value. I wish we might have passed an ordinance 50 years ago. It could have been much better and would have saved great loss."

St. Louis, Mo.—"Our zoning ordinance in effect since August, 1918. It has protected residential districts from invasion of inappropriate structures and seems to have general approval. We have had to make some amendments to the original ordinance to meet the requirements of St. Louis's large industrial expansion during the past year. The zoning ordinance should meet with great approval, but should be sufficiently elastic to meet changing conditions."

Alameda, Cal.—"Zoning ordinance protecting industries, business and homes in effect just one year. Already we see beneficial results, especially in regard to protection of homes and business. Too early to say much about assessments, but we believe this ordinance will tend to stabilize them. General satisfaction expressed throughout the city."

Minneapolis, Minn.—Minneapolis Real Estate Board is a unit in believing that zoning conserves real estate values and promotes an economical and logical growth. We are trying to obtain a zoning plan for Minneapolis. At the present time we have succeeded in getting a law providing for a city-planning commission, but due to opposition of short-sighted members of our city council it is not as yet functioning. We have already, under a law adopted in 1915, established a large number of residential districts, but this is proving a poor substitute for a comprehensive city plan, and many residential neighborhoods, consisting of modest homes, as well as fine homes, are

being destroyed by incursions of apartment houses and stores. Minneapolis is going to have a comprehensive zoning plan if it has to elect an entirely new city council to get it."

Chicago, Ill.—"Common Council of Chicago today (Feb. 18, 1920) unanimously approved building zoning ordinance proposed by Cook County Real Estate Board. We believe comprehensive zoning regulations give stability to land values and prevent commercial depreciation of building values. We expect our regulations greatly to enhance total valuations of real estate in Chicago."

New York City.—"Real Estate Board of New York has followed zoning plan since inception and sat in conference with framers of original regulations. Helped upholding constitutionality. Majority public sentiment here approves zoning plan and general effect is undoubted stabilization of values and rents. Wartime restriction of building retarded operation of law, but regulations are working out systematically."

St. Louis, Mo.—"The zoning regulations adopted two years ago are not popular with many real estate agents, since they prevent the indiscriminate sales of vacant lots for every use. They have considerable merit in this, that they prevent the invasion of apartments or business buildings in residential districts. I am not of the opinion that they stabilize values or help conditions; our zoning regulations are not elastic enough in this, that no change can be made in certain districts without the consent of a majority of the property owners."

HOW TO SECURE A BETTER STREET LIGHTING SYSTEM AT A REDUCED EXPENSE

By Frank Koester, Consulting Engineer and City Planning Expert, 50 Church Street, New York, N. Y.

All municipalities face the problem of raising taxes to meet the ever-increasing yearly budget. This is caused in no small degree on account of the losses sustained, due to the dry laws. Cities with a population of 50,000, for instance, lose as much as $100,000 per year in revenue, and as city employees receive higher salaries (at least they should) due to the increased cost of living, and as all new municipal construction work is at least 50 per cent. higher than it was before the war, it will be seen what efforts cities must make to meet the yearly bill.

In the present article I am outlining a plan whereby a community may save many thousands of dollars yearly on a single item of the budget. It is the municipal lighting whether operated by the city or by a privately owned local light company.

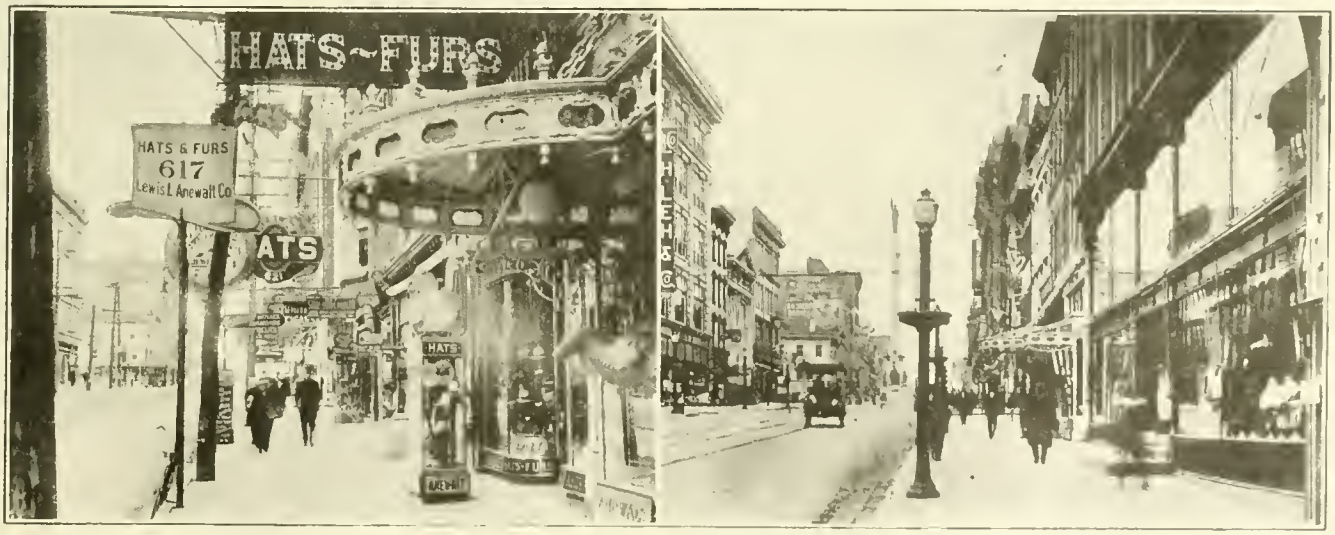
From an engineer's point of view, it is simple. However, considerable handicap, if not failure, may be met, if the plan is not scientifically prepared and presented in proper shape.

The nitrogen filled Tungsten lamp consumes one-half of the amount of electric current as the various types of arc lamps so much used throughout the country; while the common incandescent lamp consumes about one-quarter more current than the first mentioned lamp. Herein the plan of saving is indicated.

Due to the fact that many city officials hold their positions due to political favors, many administrations will not dare to "buck up" against the local light company, which, as a rule, is connected directly or indirectly with the trolley company. The latter, within recent years, has been demanding higher fares, claiming that otherwise they will be forced into bankruptcy.

Once in a while there is a city official with sufficient independence to introduce a resolution calling for an investigation of the street lighting system. Such were the cases before the writer was retained by some cities in Pennsylvania.

My investigations in these cities also covered the financial aspects of the electric companies in the respective cities, and it shows that the trolley companies' claims for increased fares are not always warranted. For instance, in one city the local light company, which previously was an independent concern, is now "owned" by the traction company, which had a net earning of 32 per cent. in 1917, the very year when this company demanded increased fare and ever since has received 7 cts. instead of 5 cts., the old-time fare. This latter company is "controlled" by another out-of-town corporation, which had a net earning of 41 per cent., and this latter corporation is "under the management" of a New York corporation which had a profit of 54 per cent. and, again, this latter

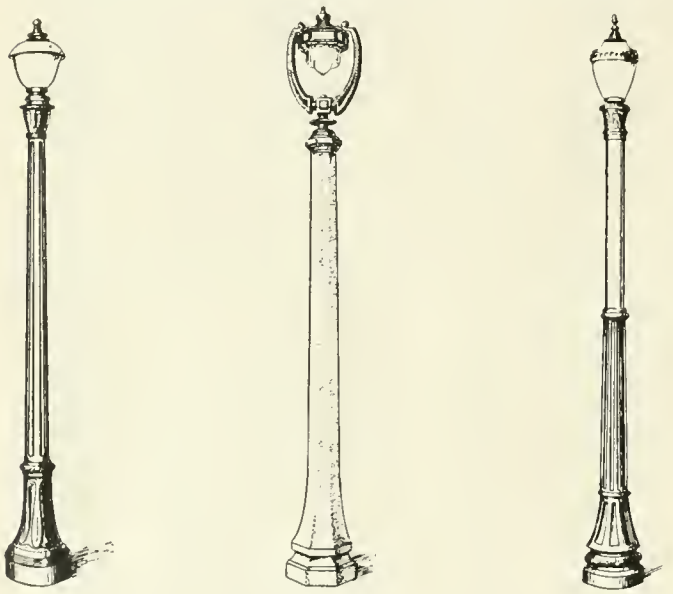


VIEWS OF HAMILTON AVE. AT SIXTH STREET, ALLENTOWN, PA., BEFORE AND AFTER REMOVAL OF SIDEWALK OBSTRUCTIONS.

organization is "controlled and all common stocks are owned" by a big manufacturing corporation.

Now, it is known that within recent years, the earnings of a trolley company are not as good as that of an electric light and power company. Therefore, the light company in question had to support the trolley company at the expense of electric current consumers. And as the trolley company is being "controlled," "managed" and "owned" by three different outside corporations, it will be seen that the consumers of electric current must foot the bill.

Another problem of the city officials, who handle the taxpayers' money for street lighting, must be met if they are aware of the following facts. A large number of local electric companies are practically forced to buy all their needs from the manufacturing company which "controls and owns all common stock" of the "managing" and "controlling" companies, as stated above. This means



THE HEIGHTH OF POST DEPENDS DIRECTLY ON THE CANDLEPOWER OF LAMP AND EQUALLY AS MUCH ON THE TYPE OF GLOBE OR REFRACTOR.

that the local electric company must buy at the prices of and from this particular manufacturing company, and if such a manufacturer produces globes for street lamps, these globes will have to be installed regardless of the cost and efficiency of the globe.

Now, 50 per cent. of the illuminating effect in street lighting lies in the globe or reflector. My tests show tha a 250 candle power nitrogen lamp with a certain globe gives a very much better illumnating effect than a 600 candle power nitrogen lamp provided with another type of globe. This, as well as the height of the lamp, above street surface, is a very important factor to be taken into consideration. If a boulevard lighting is to be installed, the design of the posts to harmonize with the surroundings and their spacing are other not to be neglected considerations.

Many electric companies demand higher remuneration for their service, claiming higher cost of producing electric current, etc. These companies as a rule advance the argument that coal and labor are about twice as high as they used to be. This is true; but with skillful engineering, the final cost per kw.-hour generated is not much higher, if any at all, than it used to be 10 or 20 years ago, because the efficiency of the power plant as a whole is about twice as high as it used to be. Today nearly twice as much steam as then is being generated per pound of coal, and while the prime-movers used to consume 25 to 30 lbs. per kw.-hour, today they consume but 14 to 16 lbs.

Conditions in Allentown, Pa.

While the foregoing various facts were recognized by the city officials of Allentown, Pa., the city retained my services to make an investigation of their street lighting system.

The city of Allentown, Pa., for the year 1918 paid the local electric company for services rendered $49,635. For 1919, it was $51,066 for street lighting and $2,200 for lighting the various mnuicipal buildings, or a total of $53,260. At 4½ per cent. interest, this yearly payment represents a capital of $1,183,600.

This report shows that for a municipally owned system, a capital of $155,206 is required, while the yearly total operating cost, including interest on the capital and depreciation of the entire system, with coal at $4 per ton, will be $36,866 and with coal at $5 per ton, $40,853. Therefore, a yearly saving of from $12,413 to $16,400 will be effected, if the city owns and operates the street lighting system, using Nitrogen filled Tungsten lamps of the same candle power as the present arc lamps. The city could pay off all the borrowed capital within 10 to 15 years.

While Allentown in 1916, according to my City Planning Report of 1915, installed on the main business streets a boulevard lighting system of single lamp ornamental posts (14 per 430 ft. block, or 7 on each sidewalk), in the rest of the city, the old arc lamp was retained. This is a 4 ampere series type lamp, and, while it consumes 320 watts, my tests made (with newly calibrated standard instruments), showed that the candle power was, at best, but 249.3 candle power; that is, when the arc lamp was specially prepared for the test and provided with new carbons and a new globe while it was generally believed to be 800 candle power. This latter figure, however, was "nominal" candle power, and this, in modern science means anything and nothing. The fact remained that these arcs were actually not quite 250 candle power under the most favorable conditions, and for this reason a calibrated Nitrogen filled Tungsten lamp of 260 candle power (manufacturer's rating 250 c. p.), was selected as a standard for comparison. The light value of the arc lamp at 20 ft. distance was 87.5 per cent. and at 70 ft. distance, it was 95.9 per cent. that of the Nitrogen lamp. The Nitrogen lamp was provided with a Holophane refractor, while the arc lamp had a new clear glass single globe. In addition the former lamp gave a steady light while the latter, as all arcs do, gave a very unsteady light.

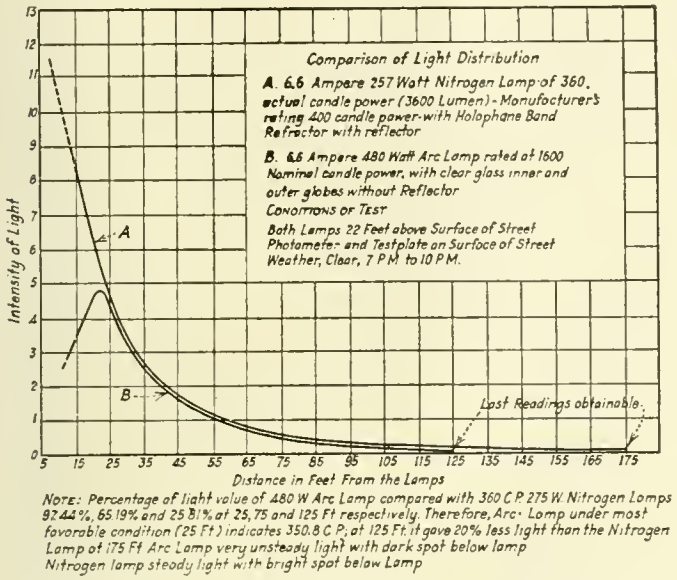
After this report was handed by the city to the local electric company, that company offered to install free of charge the lamps proposed and charge per lamp $40 instead of the $64 the company was getting for the antiquated arc lamp.

Conditions at Scranton, Pa.

Due to the results obtained in Allentown, the city of Scranton retained my services to make a study of their

lighting system and the results of the study are as follows:

The city has at present 1.286 arc lamps of 6.6 amperes and 480 watts, which cost the city $50 per lamp per year, and 77 Tungsten lamps of 80 candle power (100 watts) at $15 per year. In addition, current is being used in some 40 municipal buildings for light and power. The cost for light is 10 cts. for the first 150 kw. hour, 9 cts.


Comparison of Light Distribution
A. 6.6 Ampere 257 Watt Nitrogen Lamp of 360 actual candle power (3600 Lumen) - Manufacturer's rating 400 candle power with Holophane Bowl Refractor with reflector
B. 6.6 Ampere 480 Watt Arc Lamp rated at 1600 Nominal candle power, with clear glass inner and outer globes without Reflector
Conditions of Test
Both Lamps 22 Feet above Surface of Street
Photometer and Testplate on Surface of Street
Weather, Clear, 7 P.M. to 10 P.M.
Intensity of Light
Distance in Feet From the Lamps
Last Readings obtainable
A
B
0 1 2 3 4 5 6 7 8 9 10 11 12 13
5 15 25 35 45 55 65 75 85 95 105 115 125 135 145 155 165 175

Note: Percentage of light value of 480 W. Arc Lamp compared with 360 C.P. 275 W. Nitrogen Lamps 97.44%, 65.19% and 25.81% at 25, 75 and 125 Ft respectively. Therefore, Arc Lamp under most favorable condition (25 Ft.) indicates 350.8 C.P. at 125 Ft. it gave 20% less light than the Nitrogen Lamp at 175 Ft. Arc Lamp very unsteady light with dark spot below lamp
Nitrogen lamp steady light with bright spot below Lamp

CHART NO. 1. RESULTS OF STREET LIGHTING TESTS MADE AT SCRANTON, PA., ON NOV. 2, 1919.

for the next 100 kw. hour, and 8 cts. for all in excess of 250 kw. hour. The total bill for the year ending Nov. 30, 1919, was $69,555.85. Many of the municipal buildings receive current free of charge, and if figured on the above basis this amounts to $10,687.53.

The tests made on the 480 watt arc lamps which were specified in the contract made 10 years ago as 1,600 nominal candle power, proved them to be, under the most favorable conditions, but 350.8 actual candle power. A 400 candle power (manufacturer's rating) Nitrogen lamp, when calibrated in a testing laboratory, was found to be 3,600 lumen or 360 candle power, 257 watts and was used in the comparative tests as a standard and set down as 100 per cent. It proved that the percentage of light value of the 480 watt arc lamp, compared with the 360 candle power, 257 watt, Nitrogen lamp was 97.44 per cent., 65.19 per cent. and 25.81 per cent. at 25, 75 and 125 ft. distance, respectively. Directly beneath the arc lamp, as with all arc lamps, was a very dark spot, and it was very difficult to make the first readings at 15 ft. distance on account of the great fluctuation which is more noticeable at close range; while the Nitrogen lamp gave an intense uniform light.

With the arc lamp at a distance of more than 125 ft., no further readings could be made with the instrument, while with the 360 c. p. Nitrogen lamp, the last readings obtainable were at 175 ft. distance; therefore, under the most favorable condition, at 25 ft. distance, the arc lamp, when compared with the 360 c. p. Nitrogen lamp, indicated but 350.8 candle power. As stated above, the arc lamp throughout the readings, as will be seen in the accompanying chart No. 2, gave a very fluctuating light while the Nitrogen lamp, a steady light. In addition, the arc lamp consumes 480 watts, while the 360-candlepower nitrogen lamp but 257 watts.

I wish to point out here that the arc lamp, for testing purposes, had new inner and outer globes, and in order to establish the illuminating value of an arc lamp not especially prepared for these tests, I conducted a test on such an arc lamp. It showed that this lamp had an illuminating effect of but 53.2 per cent. of the illuminating effect of the arc lamp especially prepared.

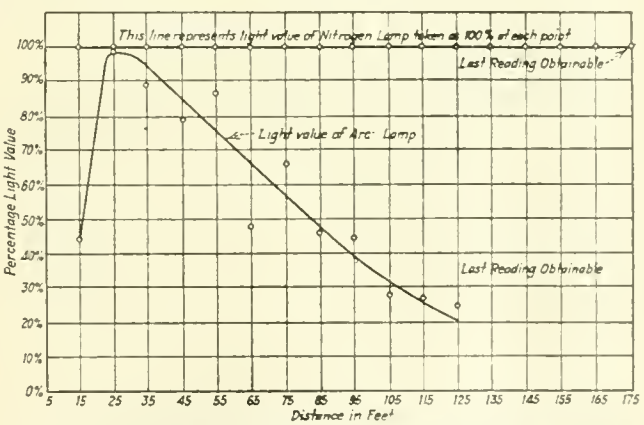
Superiority of Nitrogen Filled Tungsten Lamps

Therefore, the proposed 400-candlepower, 276-watt, 6.6-ampere Nitrogen-filled Tungsten lamp proved to be superior in every respect to the Scranton arc lamp, because—

1. It gives greater illuminating effect near the lamp.
2. It gives greater illuminating effect at a greater distance.
3. It does not require as much attention.
4. It does not produce, when fitted with a proper globe, a glaring effect, such as all arcs do.
5. It gives a constant light, instead of flickering, as all arcs do.
6. It consumes about 57.3 per cent. the amount of electric current.
7. It will save, by substituting the arc lamp with nitrogen lamps, some $25,000 per year.

Conditions in Another Case

Besides making this test, I made a study for a municipally owned lighting system, and as the gas and water supply systems are in the hands of a private concern, there was no possibility of connecting a municipal electric generating plant with these plants. But the city possesses


This line represents light value of Nitrogen Lamp taken as 100% at each point
Last Reading Obtainable
Light value of Arc Lamp
Last Reading Obtainable
Percentage Light Value
Distance in Feet
100% 90% 80% 70% 60% 50% 40% 30% 20% 10% 0%
5 15 25 35 45 55 65 75 85 95 105 115 125 135 145 155 165 175

Curve showing percentage of light value of 480 Watt, 6.6 Ampere, 1600 nominal candle power Arc Lamp, compared with 257 Watt, 6.6 Ampere, 360 actual candle power, Nitrogen filled Tungsten lamp at various distances. Nitrogen lamp taken as 100% at each distance. Circles shown the great fluctuation of arc light

CHART NO. 2. COMPARISON OF EFFICIENCY OF ARC AND NITROGEN FILLED TUNGSTEN LAMPS.

an incinerating plant, destroying daily some 60 tons of garbage and refuse, which is collected separately by the city. If the gases of these destructors were properly utilized, from 1 to 1.3 lbs. of steam could be generated, and assuming but 1 lb., there could be generated some 120,000 lbs. of steam per 24 hours. These waste gases represent a value of $9,150, while the force at present employed receive a total wage of some $9,000 per year. This $18,000 per year is a big item in the economy of the electric generating plant. (The balance of the steam required throughout the year will be generated by crude oil or Scranton coal at a cost of $1,250 and $2,500, respective-

ly.) As the bulk of the steam is required in the night time (for street lighting), and as the garbage is being collected in day time, the plant is provided with a 60-ton storage bin.

The generating room is provided with one 200, one 300 and one 500 kw. turbo-generator set. The actual full load demand is 486 kw. when using nitrogen lamps (with arc lamps 818 kw.). The 11 electric circuits are to be fed from this plant and are overhead, with the exception of the part in the business or fire districts, where also an extended boulevard lighting system of some 400 single lamp poles (10 to 14 lamps per block, or 5 to 7 lamps on each side) is provided.

The yearly cost for maintaining the boulevard lighting is nearly $13,000, and as the total savings as above stated, is about $25,000, there may be installed throughout the city in addition 200, 100 c.p., 100, 250 c.p. and 100, 400 c.p nitrogen lamps and still leave a few thousand dollars for other purposes.

With the above described plant it will cost the city of Scranton 1c to generate 1 kilowatt hour and it will cost another 1¾c (including line losses, etc.) to bring the current to the point of consumption. (The high cost for distribution is due to the exceptionally large area of the city, namely, 25 square miles for a population of some 160,000.) In other words, should the city decide to sell current for light and power to private consumers, in which case a larger power plant would be required, and, therefore, the production of electric current would be correspondingly lower per kilowatt hour, while the distribution system would remain practically the same, figuring a net profit of 10 per cent., current could be sold at an average of 3 cts. per kw. hour, while at present the charges, as stated above, are 8, 9 and 10 cts.

Many Pennsylvania cities, recognizing the great advantage obtained in possessing a modern street lighting system, including boulevard lighting for the business streets, as a part of an efficient city planning program, are at present busy substituting the old-time arc lamp with the more efficient Nitrogen-filled Tungsten lamp. For instance, the city of Bethlehem, for which I made a comprehensive city-planning report in 1919, is now installing a boulevard lighting system of some 250 ornamental single lamp posts. The neighboring city, Allentown, installed within a year after I had made a city-planning report a boulevard lighting system of some 160 lamps on Hamilton street, which is the main business thoroughfare. Since then additional business streets have been provided with the same lighting standard. These posts are provided with flower bowls; the maintenance of the latter is about $2,000 per year. The cost of the flowers in summer and green plants in winter time is, per bowl, $2 and $1 per year, respectively.

A feature very much overlooked in boulevard lighting is the adoption of the height of a lamp post according to the candlepower of the lamp and to the kind of globe or refractor. As a rule the lamp posts are far too low for the candlepower of the lamp used; and, without going into detail, it may be stated that (if it were possible) one lamp for the entire city, like one sun for the entire world, would establish an ideal illumination.

WIDTHS AND LOADINGS FOR HIGHWAY BRIDGES*

By Lewis M. Gram, Professor of Structural Engineering, University of Michigan, Ann Arbor, Mich.

It is not so many years ago that practically all of the engineering advice relating to the purchase of highway bridges of a permanent character was furnished directly or indirectly by steel fabricators who were interested in that class of business. The specifications were uniformly simple, and little engineering collaboration was required on the part of the purchaser. The length and width were usually specified, and the capacity expressed by a uniformly distributed load as 80, 100 or 125 lbs., with a factor of safety of 4 or 5, as the case might be. In a paper read before this course a few years ago, the author discussed the ambiguity and inconsistencies of such specifications and it is not the intention now to elaborate further upon the merits or demerits of the earlier methods of procedure in this connection. Suffice to say that the amazing progress which has been made in highway engineering organization in general during the past decade or two has naturally brought about radical changes in practices relating to highway structures which form such an important part of the road system. The men nowadays who make a scientific study of the highway problems in general are of the caliber necessary to handle intelligently practically all of their bridges, at least in so far as general specifications are concerned.

The author has recently taken occasion to examine some of the publications issued by the public road organizations in various states and is gratified to see in the treatment of structures the reflection of highly competent engineering counsel. In fact, in glancing through the structural specifications as embodied in the documents of such organizations as referred to, one is quite likely to note the similarity to those of well developed railway practice. And why not? The problems are much the same and certainly no one who is familiar with the situation in structural engineering fails to recognize and appreciate the competency of the engineering corps who have been instrumental in developing railway construction to its present high standard.

Loose and general specifications are no longer sufficient in the matter of highway structures any more than for those on railways, and the highway engineer must consider it part of his duty to give special attention to each and every structure which forms an integral part of his road system. Careful surveys should be made of service requirements, both immediate and future, in order that the general specifications may be prepared accordingly. To follow the railway analogy a little further, for example, the particular highway in question, with its incidental structures, may form part of a present or future main line where the traffic is, or is likely to be, heavy and frequent; or it may be a branch line where the demands are comparatively light.

Elements in the Bridge Problem.

There are many problems which the highway engineer must take up and solve at the outset concerning the de-

* Presented on Feb. 26, 1920, at the Sixth Annual Short Course in Highway Engineering at the University of Michigan.

sign of a bridge structure, of which the following more important ones may be mentioned:

1st. Type of structure.

2nd. Material best adapted.

3rd. Capacity both as to the volume of traffic which may be accommodated at one time and as to its weight.

Loading of Bridges.

The type of structure and material best adapted are decided upon after a careful study of the economic and aesthetic features of the case in hand, and it is the intent of this article merely to discuss the third problem, namely, capacity of the structure and more particularly the weight of service traffic. At the outset it is proper to note that this point, involving as it does speculation on future requirements, can be handled with least scientific certainty. All will readily agree that in hazarding a prophecy regarding the future in highway transportation one guess is as good as another. Only a few days ago an item appeared in the public press to the effect that a patrol had been stationed along one of our recently completed public highways for the purpose of preventing the passage of motor vehicles of a capacity considered detrimental to the road structure. If that report be true, here we have an example of a transportation line excessively loaded almost as soon as it is completed for service, an engineering error, if it be so considered, which is excusable only when we stop to think of the almost unbelievably rapid development of highway transportation during the past few years; and if the roadway surface is seriously impaired by excessive loading and speed, how much more dangerous is the effect upon the bridges which it is assumed are designed for the same loading as other parts of the same road division. The following paragraph, pertinent to the situation, is extracted from an address delivered by H. E. Breed at the Highway Transport Conference in New York on January 10th.

Weak Bridges.

"There is a pressing problem before all of us, upon which you should take immediate action. You all know the danger and delays caused by weak bridges. Bridges have lagged farthest behind in improvement, because they are not regarded as an integral part of the highway system. Along roads that are bearing 14-ton loads you constantly meet bridges designed for only 10 tons. In New York State there are 33,775 bridges. Of a total of 251 bridges on three main traveled routes from the Pennsylvania State line to New York City, only 115 are built for 15 tons or over; 17½ per cent. of them are built for less than a 5-ton load. Twenty-three of them would stand less than 3 tons. On the less traveled routes the status of bridges is even worse. It is as menacing in other states as it is in New York. This matter should be rectified at once by petitioning our legislatures for funds with which to bring our bridges up to required capacity. Otherwise, the progress of our whole system is threatened by its weakest link."

But it is not necessary to go all the way to New York State for example of weak highways bridges. We have them in our own midst, and why some of our structures safely carry the loads which are passing over them daily is a miracle of science which I will not attempt to explain.

What the future development in highway transportation will be no one of course knows, but there is certainly no excuse for failing to provide for present general needs in proposed highway structures, and also for making at least modest provisions for the future. It is not out of place to ask in this connection whether the highway proper and its incidental structures should not serve as a stimulus to encourage even more rapid development of transportation facilities. There are economic propositions involved, doubtless, in an answer to this question and perhaps you have already considered it from the roadway proper angle. I wish only to say here that whatever decision may be reached regarding the roadway proper, applies with greater emphasis to the highway structures, because the weakness or failure of a single structure may tie up, for a time at least, an entire section of the highway.

Very Heavy Loads.

A study of the specifications of 29 truck manufacturers recently collected by the Highway Department of the University of Michigan discloses the fact that while practically all of them are turning out vehicles weighing from 10 to 12 tons loaded, 15-ton trucks are not at all uncommon. In view of existing traffic requirements, therefore, one can hardly be criticized or considered too enthusiastic on highway transportation to predict the commercial use of motor vehicles weighing loaded as much as 24 tons, during the reasonable lifetime of a permanent structure. Some of our state highway departments even now wisely recognize the probability of continually growing traffic demands and specify design loads of that magnitude for their permanent concrete bridges.

With regard to the volume capacity of highway bridges the ever increasing widths of motor vehicles and the speed with which they are propelled is again causing radical changes in bridge specifications. Where 18, 16, or even 14 ft. was formerly considered sufficient to provide for two lines of slowly moving traffic, many vehicles are now being used on the highways which require at least 8 ft. of width and on that basis it is my judgment that 20 ft. should be provided for two lines of vehicles on bridges of the main traveled routes, and 38 ft. for four lines of vehicles.

Distribution of Concentrated Loads.

To those who are interested in the technical design of highway structures there are various interesting points to be taken into account, some of which have already been made the subject of experimental investigation and others which should be so investigated at the earliest possible date. One such point of which mention might be made is the distribution laterally and longitudinally of concentrated loads. An engineer familiar with the designing of bridge structures will appreciate that concentrated wheel loads, instead of nominal uniformly distributed live loads, usually control in proportioning members of the floor system. A study of current practice in various states shows, however, that there is a lack of uniformity in the method of handling concentrated loads, differing by several hundred per cent. It will be seen, therefore, that for the same traffic requirements a wide range of results is obtained due to varying judgment in the methods of applying concentrated loads in the design. Perhaps the most liberal and intelli-

gent specification in this connection is that of the Bureau of Public Roads.

Impact.

A second point of technical interest upon which authorities and specifications differ widely is that of impact. To what extent should the live load be increased in intensity due to the manner of its application? This is such a complex question, affected by so many conditions incident to both dead and live loads, that much experimental data will be needed upon which to base an intelligent answer for any particular type of structure. Investigations are now under way by the Bureau of Public Roads relative to the dynamic increase in weight of the wheel of a loaded truck on a road surface, showing that an increase of 2 to 400 per cent must reasonably be expected. A study of such data rather leads one to believe that insufficient importance has been attached heretofore to the matter of impact on highway structures; and it is hoped that investigations of similar nature may be made also on structures of various types.

In closing, it would seem pertinent in view of the rapidly increasing demands of traffic upon our highways, to emphasize the importance of careful supervision and maintenance of highway structures. The engineer who is entrusted with responsibility for the highways in any given district should not only know the capacity of every structure under his care, in order that precautions may be taken to avoid accident due to inadvertent overloading, but he should see to it that the period of usefulness of every structure is prolonged by proper maintenance.

CO-OPERATION BETWEEN THE ENGINEER AND CONTRACTOR

By C. D. Franks, District Engineer, The Portland Cement Association, Merchants Bank Bldg., Indianapolis, Ind.

Just what the engineer's attitude should be toward the contractor is not so clearly understood as it should be. To draw the line of demarkation between serving our own interest and that of others—to indicate clearly by that line where our service to others ceases to react to our own interest, is a delicate and difficult task, but it is apparent to those of us who have been in position to observe that a far greater service than has been rendered could be rendered by the engineer to the contractor without touching that line or transgressing in any respect. Such service to the contractor, comprised of engineering knowledge and technical assistance, would reflect invariably to the credit and interest of the engineer, said Mr. Franks in addressing the Indiana Engineering Society.

I do not hold a brief for the contractor's interest or welfare, but it is clear to me that, if we are to get the high quality work, the reasonable construction cost, and the record time operation, all of which we so much desire, it is up to us to help the contractor in our negotiations with him and to endeavor to accept more of his viewpoints than has been our practice heretofore.

Not only are the State Highway Commissions of the country outlining in a definite way highway programs for this year and several years to come, but county and city officials are more keenly interested in pushing highway and street construction work than they have ever been before. Millions of dollars are being appropriated and spent in all lines of building construction, and the men who play the greatest role in the execution of these various construction programs are the engineers and the contractors.

Getting the Contractor's Viewpoint

There are many new contractors doing highway work and they have not figured properly upon the contingencies which must be met, but whether the chief reasons for the loss of money are to be found in the contractor's methods of handling his work or in conditions imposed upon him by the engineer is a debatable question. Be that as it may, the fact remains that the engineer can do much toward overcoming the losses and more especially the difficulties of the contractor, if he will but assume to a greater extent, than has been the practice, the contractor's viewpoint.

In other words, the engineer in charge of the work would, under this plan, use the same methods and consider the same items in estimating his costs as would the contractor in figuring his bid price. In this connection, and singularly enough at this time, the Wisconsin Highway Commission held a conference at Madison, December 2-4 inclusive, which was attended by nearly 200 representatives of the road building forces of the state, including county engineers, contractors, machinery and materials interests. Difficulties and grievances arising during the past season were freely and frankly discussed and in nearly every case solutions were agreed upon which will help to rapid progress the 1920 program. This now involves about 400 miles of concrete roads. A permanent committee was organized which will be known as the Uniform Cost Accounting Committee, which will collect data on the factors affecting costs and estimates so that the information may be available for next year's work. This Committee consists of twelve, five of whom represent state and county interests, five of whom represent the contractors and one each the machinery and materials manufacturing interests. This meeting was out of the ordinary in many ways and constituted an important step toward solving the difficulties presented by a large road-building program.

Getting Reasonable Prices

The engineer is naturally desirous of securing as reasonable bid prices on work as possible. He acts as the agent of the taxpaying public in township, county or state, and that public looks to him for an economical expenditure of its funds in the construction of highways. If reasonable prices are to be expected from contractors for construction work, then certain concessions must be made to them with this end in view. The causes which create high prices can be removed, naturally resulting in lower prices, but a lower price level, under existing conditions, would be less reasonable or fair than present prices.

Whenever the contractor is in doubt, when he is confronted with uncertainties, when he assumes certain extremely indefinite hazards, he endeavors to cover up or secure himself against possible loss by making his bid price accordingly. At this time in the majority of paving contracts the contractor assumes all the hazards and in proportion to the risks and hazards incurred does his bid prices increase.

Two Classes of Hazards

The hazards to be encountered may be divided roughly

into two classes. First, those, which although usually inevitable, it is nearly impossible to assign just to what extent the cost to the contractor has been affected, even after the work is completed. Under this class would come the hazards due to weather conditions, shortage of labor and inadequate transportation facilities.

The second class covers those hazards which, when they occur, the financial effect upon the contractor can be definitely calculated. For example, a revision in freight rates during the life of the contract. Under this condition the contractor could readily show in a definite way how much more or less the work cost by simply computing the difference in freight rates on the materials involved.

These examples are perhaps sufficient to indicate the classification of hazards, the majority of which, if not all, the contractor considers when figuring his bid price. His additional cost for assuming these hazards is in the nature of insurance. If the risk or hazards were removed, then there would be no need for an insurance charge and the bid price would be proportionately less. It is, of course, generally conceded, that the aforesaid risk or hazards of the second class, could be better and more economically assumed by the public, and until such a change in our method is brought about the contractor will continue to make an appreciable charge for this invisable yet certain insurance feature.

Flexible Contracts

Contracts should be so drawn as to relieve the contractor of every uncertainty and hazard which it is possible to foresee. Surely every contract should provide for an adjustment in case freight rates are changed subsequent to the execution of a contract; if revised upward then additional compensation for the contractor, if downward, like advantage to the public. If, in order to hasten completion of work and to avoid delays, which are always costly to both the contractor and the public, it would appear desirable that materials be stored on job in quantities, the contractor should be allowed a reasonable advance on such materials. If required to store materials but paid only for completed work, the contractor must, in protection to himself, charge for the service and subsequent risk, and this charge included in the contractor's bid price would be more than would the cost to the public for advancing to the contractor sufficient funds to pay for the stored materials.

Removing Uncertainties

However, it is not so important here to give specific examples as it is to call attention to the fundamental principle that the bid prices will be reduced in proportion to the risks and hazards from which the contractor is relieved. The engineer may well consider every risk and hazard which may arise during the designated term of any contract, and so draw his specifications and contracts as to relieve the contractor of every uncertainty possible. A method which imposes upon the contractor all the risks and exacts that he do all the guessing is both costly and unbusinesslike.

THE MAINTENANCE OF MACADAM ROADS

By L. G. Quigley, M. W. S. E., The Barrett Co., 10 S. La Salle St., Chicago, Ill.

In localities where macadam roads now exist, the question the engineer has to ask himself is whether or not he can put the old road in shape and maintain it acceptably to the public for less than the interest and depreciation charges on a new road. In the case of building new macadam, the question is whether or not the interest on the difference in cost between the macadam and the more expensive types would maintain the macadam road.

By "macadam" we are only considering the roads built of slag or broken stone, the voids of which are filled with screenings or fine gravel and bound together with water and rolling, and not the so-called stone road, dumped, not built, in the center of a dirt road with blind faith that it eventually will be a road.

Three Methods of Maintaining Existing Roads

There are three primary methods of maintaining existing roads:

1. By scarifying and reshaping with the possible addition of new stone, and rebinding with water and rolling.
2. By patching.
3. By surface treating with hot or cold bitumens.

Reshaping

The first method is efficient and economical only on very light traffic roads where scarifying is necessary at long intervals, say not less than three years. The surface stone should be loosened and ploughed up with some form of scarifier used in connection with a roller or tractor. This should be done to the average depth of the holes, usually between 2 and 4 ins. The loose material should then not only be shaped to proper crown but should be thoroughly mixed by the use of the blade grader. By simply grading the loose material, spots of fine material are left which would again soon become holes. The loose material should therefore be moved several times to insure a uniform surface of coarse and fine stone. The road should then be thoroughly saturated with water and rolled. If the work has been properly done, it is seldom necessary to add more screenings except when more coarse aggregate is placed on the road. A mat of screenings should never be left on the surface. It looks pretty on the road but is not so nice on the clothes of the users of the road and on the surrounding landscape.

Patching and Surface Treating

The macadam can be maintained efficiently by the patching method only where surface treating follows; therefore, we will consider these methods together. When an existing macadam road that has been neglected is to be revived, the question that comes up is whether it is best to bring the surface to true crown and grade by scarifying or by patching. Surface treating alone will not make a bad road good.

Where the cost of patching nearly equals or is greater than the cost of scarifying, scarifying is to be preferred, as this method when handled as above described gives a uniform surface for bituminous treatment.

If the surface has a few holes, but it otherwise in good condition, patching should be done. It is hardly necessary to say that this patching should be done only with the use of bitumen, and never with stone or screenings alone, since even when surface treated, such a patch is never thoroughly bound and easily breaks out. When hot refined tar or asphalt is to be used, the hole should be

first thoroughly cleaned and the edge trimmed so that the sides of the hole are nearly vertical and then filled with stone that will pass a 2¼-in. ring, and be retained on a 1¼-in. ring. Smaller sizes are called for in shallower holes. The stone should then be tamped or rolled and then covered with hot bitumen, using approximately one gallon per square yard of surface per inch in depth. The bitumen should be immediately covered with ¾-in. chips and thoroughly tamped and rolled.

Care should be exercised that the finished patch is not higher than the surrounding surface. Patching has been made much easier by the introduction of cold patching tar, which can be mixed cold with sand and stone either by hand or in a concrete mixer. The resulting mixture is rolled into the holes and ruts and sets up finally like the bitumen applied hot. This method requires little equipment and a large mileage can be handled rapidly.

Surface Treating New Macadam

In surface treating new macadam it is generally advisable to open the new road to traffic for a few weeks to permit vehicles to loosen up any caked fine material on the surface. When the road surface is dry it should be thoroughly swept with rotary horse-drawn brooms or by hand-brooming or both. It is very essential that every bit of loose material be removed from the road. The bitumen should then be applied, preferably with pressure apparatus, or, if gravity distribution is used, a decided improvement can be made by using a broom drag directly behind the distributor. This broom drag is constructed with 4-in. strips to make a frame approximately 4 ft. by 8 ft. using push broom heads on the 8-ft. side. Both the pressure distribution and the broom drag insure that the bitumen thoroughly penetrates into the top surface of the road.

The only bitumens that should be considered for this class of work are the refined tars applied either hot or cold, or the heavier grades of asphaltic base oils. The light dust-laying oils have no binding qualities whatsoever and depend upon weighting down the dust particles to keep the dust from flying. For the first application on a newly treated road about ½ gal. to the square yard should be applied. If cold bitumens are used, it is a decided advantage that this first application be made in two ¼ gal. treatments, since there is less chance for wasting material, and it permits better penetration into the road surface.

When hot refined tar or asphalts are used, it is quite necessary that the macadam surface presents a nubby or grainy appearance. Hot applications do not penetrate into the surface of the road, but depend for their efficiency upon the mat sticking to the surface. The hot surfacing is best suited for roadways on which a large majority of the vehicles are pneumatic tire pleasure vehicles, such as boulevards and light residential traffic streets.

The covering for the cold bitumens should be as large in size as the bitumens will retain on the road surface, and this covering should be applied sparingly, as an excess of covering tends to blot up the bitumen from the surface of the road and lessen its penetrating qualities. The size to be used with hot bitumens runs larger, and should be the hardest kind of road metal, as this kind of covering will prevent creeping and rutting of the road surface.

It is also an added advantage when using hot surfacing to roll the road metal into the bitumen, as traffic is very apt to throw a large amount of the chips off the surface that would otherwise be bound by the bitumen.

Making Repairs

After the macadam road has been properly treated the first time, it is very easy to keep it in an excellent state of repair. It should be regularly gone over and the small holes that develop should be immediately patched as described above under patching. When the first surface treatment begins to show signs of wearing through, it is advisable to give it another treatment. The second and succeeding applications as a rule should be about one-half the amount per square yard used in the first treatment. Care should be taken not to build up a thick covering on the road surface. A thick covering is not an advantage and may be a disadvantage, as it is very apt to shove into waves or rut badly.

The Cold Penetration Method

Building the maintenance into the road is a new idea in macadam road building. Some localities call it the cold penetration method. In a few words it consists in building the macadam road as ordinarily built with the exception that when filling in with screenings cold refined tar is applied in three or four applications much the same as water is used in ordinary macadam construction.

It can be readily seen that this is not a very expensive proceeding, and in many cases the water has to be hauled from a long distance, so the difference between the cold tar penetration and waterbound macadam is small. The macadam road built in this manner presents an ideal surface for future maintenance. LaCrosse County, Wisconsin, has had decided success with this method of construction, as well as many other counties in Illinois and other states.

The macadam road maintained, as above outlined, we believe, solves to a large extent the problem which confronts so many county and suburban localities.

The foregoing is the major portion of the address recently delivered by Mr. Quigley at the University of Illinois Road School.

THE ROAD-MAKING MATERIALS OF NEBRASKA

By A. S. Mirick, Chief Construction Engineer, Nebraska Department of Public Works, Lincoln, Neb.

Platte River Gravel

The most valuable road-making material we have in Nebraska at present for both surfacing, concrete bases and concrete paving is the Platte River gravel. This material is pumped from the Platte River. The effluent of

the pump carries the sand and gravel to a system of sorting screens and chutes, where the finer materials are returned to the lake pit. The gravel is delivered to the bins; about one car load of gravel is produced to two car loads pumped. A typical analysis of this material shows the following composition:

Passing ¾-in. screen, retained on ½-in. screen	2.0%
Passing ½-in. screen, retained on ¼-in. screen	12.7%
Passing ¼-in. screen	85.3%
Retained on ¼-in. screen	14.7%
Passing ¼-in. screen, retained on 10-mesh	44.7%
Passing 10-mesh screen, retained on 20-mesh	27.9%
Passing 20-mesh screen, retained on 30-mesh	5.5%
Passing 30-mesh screen, retained on 40-mesh	3.1%
Passing 50-mesh screen, retained on 80-mesh	1.9%
Passing 80-mesh screen, retained on 100-mesh	0.2%
Passing 100-mesh screen, retained on 200-mesh	0.5%
Passing 200-mesh screen	0.5%
Loss by washing, silt or clay	0.4%

The character of the material consists essentially of rounded fragments of granite, quartz and quartzite with a large amount of sub-angular quartz sand.

You will see that if the dividing line between sand and gravel is the ¼-in. mesh sieve, very little of this material can be called gravel. The fineness of its composition has always perjudiced highway officials as to its suitability for concrete pavement. However, last summer a test was made of the material at the Bureau of Public Roads, Washington, D. C. Two 6x12-in. cylinders were prepared, and aged 7 days, of Platte River gravel, mixed one part of cement and three parts of gravel. Two cylinders of concrete made of screened Potomac River gravel mixed one part cement by volume to 1½ parts of Potomac River sand and three parts of Potomac River gravel. The average total load sustained by the Platte River gravel cylinders was 62,145 lbs.; the Potomac River gravel sustaining a load of 57,980 lbs. The unit load in pounds per square inch was 2,198 lbs. for the former and 2,050 lbs. per square inch for the latter.

A later test of this same material mixed in proportion by volume of one part of cement to 2½ parts of sand gravel sustained a total load of 84,850 lbs. or a unit load of 2,800 lbs. per square inch. As a result of these tests it was decided to use this material for concrete pavement and as a base for other classes of paving throughout the state. This material can be obtained any place along the Platte River and will aid and also hasten the building of hard roads within the state. The material can be produced cheaply in comparison with other material and the supply is unlimited.

Bank Gravel Deposits

The material next in importance is our bank gravel deposits. These are widely distributed throughout the state and can be used both for concrete and for road surfacing. They are, in general, rather fine in composition, but compare very favorably with the Platte River sand gravels. As we progress westerly through the state the composition of our gravel becomes coarser, and in the extreme western part of the state to use the gravel supplies economically, the coarser materials will have to be crushed.

Rock Deposits

Rock deposits outcrop in the eastern, western, southern and northern part of the state. In general the most useful rock for road-making material is the limestones found in the southeastern part of Nebraska. A large tonnage is produced annually and is used for all kinds of construction. The leading quarry companies operating in the state are the Burlington Quarry, South Bend, Natural Stone Co., and the Murphy Construction Co., Louisville; Woodworth Quarry, Meadow; Atwood Quarry, Cedar Creek; Western Stone Co., Nehawka; Olson's Quarry, Weeping Water; Davis Quarry, Wymore; Blue Springs Quarry, Blue Springs. This stone has been used for macadam roads, concrete bases, and all engineering structures. The test of samples of the various stone show a French coefficient of wear from 5 to 11. If care is taken in the quarrying operations to eliminate the shale that occurs with the limestone, a quality of stone can be produced that will be suitable for any class of pavement.

The limestones in other parts of the state are soft and are suitable for temporary surfacing. The northern and southern limestones of the Niobara groups are valuable for the manufacture of cement and there is room for considerable development in this industry within the state. In the northwestern part of the state, so-called magnesia rock is found. This rock has the property of binding the sandy soil in the region where it is found. If the road is kept moist, it makes a splendid road. The riding qualities of these roads are equal to a good macadam pavement, and it is much cheaper to maintain.

Imported Aggregates

Where coarse aggregates are used in pavements, subject to abrasion, it has been the practice of many cities in the past to import Sioux Falls granite, so-called. This stone is a hard sandstone and is very durable; many fine stretches of pavement have been constructed out of it.

For asphaltic concretes and minor concrete work, it has been the custom of the southern tier of counties to import Chatz or tailings from the zinc mines of Joplin, Mo. The use of this material has been fairly economical in the past when freight rates were low; however, at the present high rates it is classed as costly.

Sand Deposits

The sands in the various parts of the state are mostly river deposits and are of an excellent quality. In the central part of the state the deposits are ideal for sheet asphalt, both as to grading and quality. Good concrete sand is found abundantly. Most of the deposits are river deposits, and the chief characteristics are the hardness of its grains and its cleanliness.

Temporary surfacing is necessary in many parts of the state. In the north and central west part of the state we have the sand hill region. This area comprises about 20,000 square miles and is the pasture land of Nebraska. The surface of this region has been shaped by the wind and presents a varied and grotesque appearance. It is mostly grassed over, and traveling over the sod is not difficult. However, if the hills are cut down, or any grading attempted it is practically impossible for traffic to go through it. The sand hill roads of Nebraska are one of our problems. We know that a brick or concrete pavement would answer the question admirably; but in a country where it requires 11,000 acres of land to graze 1,000 head of cattle, you may be sure the population is

sparse to say the least. This region will never be able to build hard roads until the state, by means of a bond issue, takes care of the roads through the region. Therefore, the State Highway Department is interested at present only in temporary surfacing. On the level stretches, it is better to leave the road as nature left it with the prairie grass still on it. But where the hills have to be cut down some sort of surface is necessary. Of course where there are deposits of clay or alkali mud in the region, a sand clay surface can be constructed that will answer the purpose very well. Where supplies of this nature do not abound, the sand hill road builder has recourse to the only available material he has—hay. He hays the road twice a year and up to the present time is still doing it, and I am afraid he will still continue to do so for several years to come, for it is the only practical road-building material he has at his command.

The supply of road material is not the most serious matter with us, for our quarries and gravel pits can produce enough material to supply our wants. The great trouble is to secure cars to ship the materials to the consumer. The production, therefore, is not proportional to the demands or to the capacity of plants, but is directly proportional to the open top cars available. Besides the lack of transportation facilities, the shortage of labor is always with us, and will be the greatest factor in curtailing road progress this year. Nebraska, in the face of these handicaps, feels that if she cannot build hard surfaced roads now, she can at least prepare the grades for them.

Acknowledgment

The foregoing is from an address by Mr. Mirick before the conference of Mississippi Valley Association of Highway Officials held in Chicago early in February, this year.

METHOD AND COST OF CONSTRUCTING GRAVEL ROADS IN WILSON COUNTY, KANSAS

By M. W. Watson, State Highway Engineer, Kansas Highway Commission, Topeka, Kas.

Wilson county, Kansas, located geographically in the southeastern part of the State, is in one of the large oil-producing regions of the United States. This reason, if no other, makes it necessary to employ some type of hard surfacing on the main traveled roads of the county. The county engineer, county commissioners and others interested in road affairs made a careful investigation of available materials and found that an abundant supply of road gravel could be obtained in practically all of the west two-thirds of the county. This gravel is usually found in slight knolls under from 1 to 3 ft. of soil and is obtainable at the small cost of 6½ cts. per cubic yard.

The gravel ranges in size from fine material to that passing a 1½-in. ring and contains about 12 per cent. of clay binder. It has exceptionally good bonding qualities and considering the low first cost and ease of maintenance, the decision of the road officials to adopt the gravel type for their county road system is certainly logical.

Finances

The laws of Kansas permit the formation of a benefit district for the improvement of a section of highway. The petition must contain a complete description of the proposed improvement, the land lying in the district, the type and width of the improvement and the number of annual assessments, from 10 to 20, over which the cost is to be distributed.

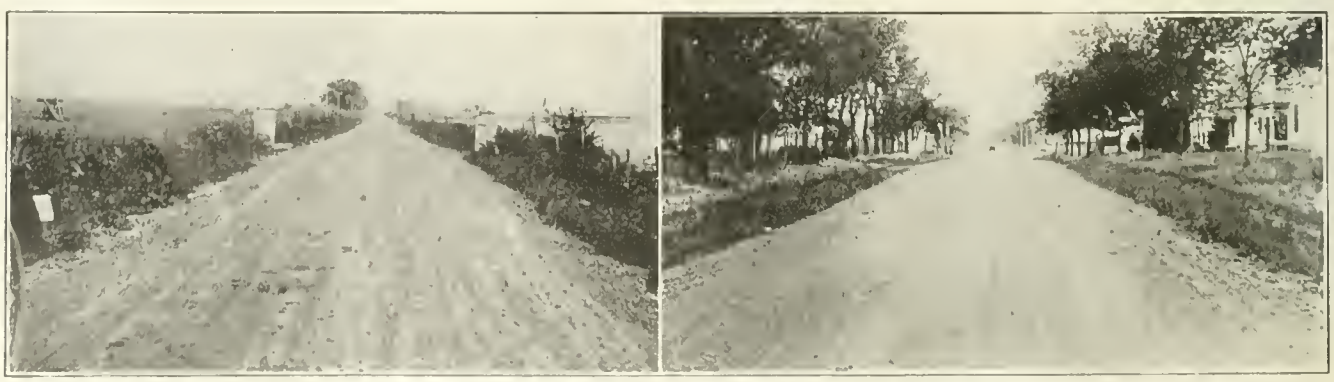
The district for gravel road work is usually about 1 mile on either side of the proposed road. The law requires that the petition must contain the signatures of 51 per cent. of the resident land owners, owning 35 per cent. of the land, or 35 per cent. of the resident land owners, owning 51 per cent. of the land, or the owners of 60 per cent. of the land lying within the district. By resident land owners the law refers to any persons owning land in the district and living in the county. After the petition has been properly signed it is presented to the board of county commissioners and they, by appropriate action, declare the road to be a public utility and order the surveys and plans prepared by the county engineer. After the surveys have been made and the plans prepared the plans and estimates are submitted to the State Highway Engineer for his approval, after which the board of county commissioners may either award a contract or construct the work themselves. The latter method has been selected by the board of county commissioners in Wilson county.

Labor

The bulk of the labor employed on this work is obtained from farmers. Floating labor usually is unobtainable owing to the location of the county in the oil region, where much higher wages are paid by oil companies than could be paid on this class of work.

Earth Work

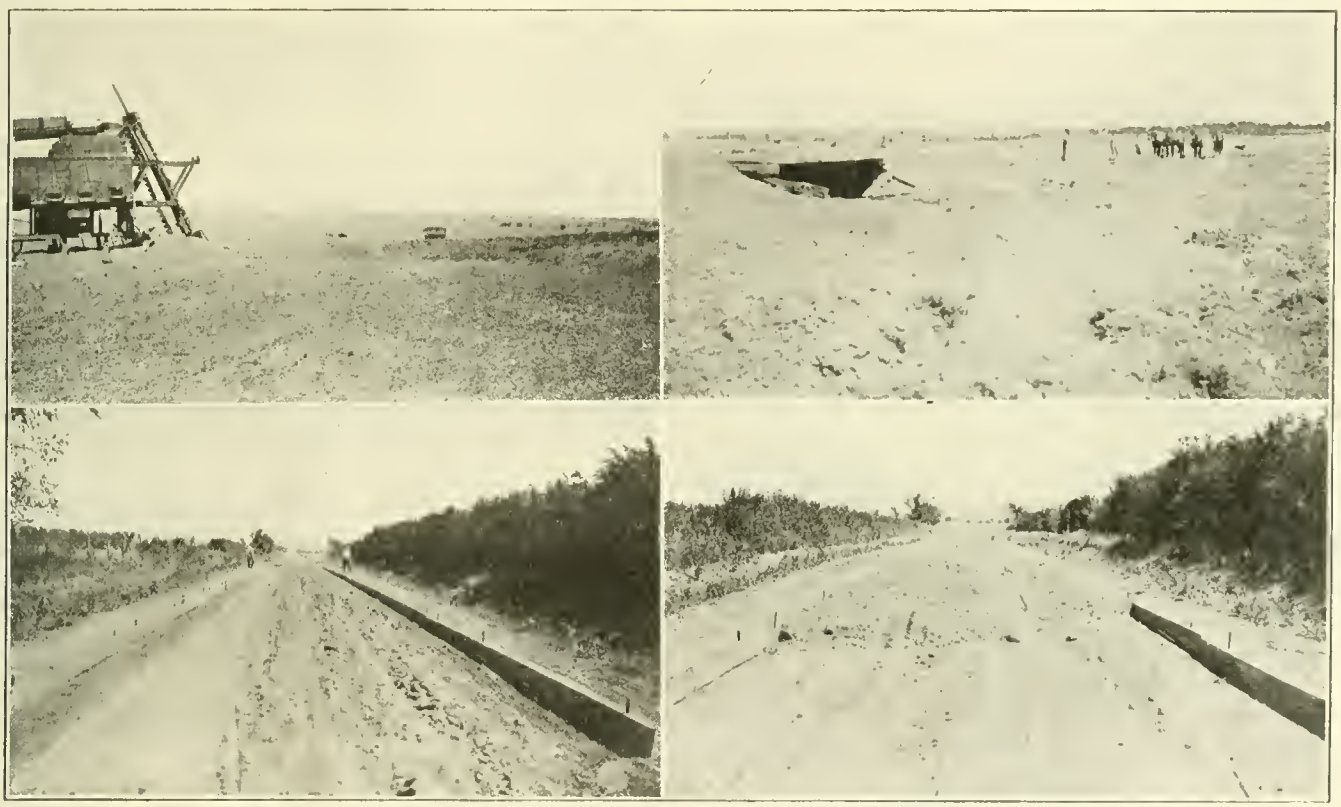
Much attention is given to the preparation of a proper



VIEWS OF FREDONIA-BENEDICT (COLEMAN PROJECT) GRAVEL ROAD IN WILSON COUNTY, KANSAS, AFTER SIX MONTHS' AND ONE YEAR'S SERVICE RESPECTIVELY.

roadbed before placing the gravel. Since the roads are slightly rolling and the soil is of clay and the gravel used possesses excellent bonding qualities, the feather-edge method of construction is found to be most desirable. The sub-grade is constructed with a crown of about ¼ in. per foot, without any shoulders to obstruct proper drainage of the sub-grade previous to final compaction. The side slopes from the berm into the ditch are 2½ ft. horizontal to 1 ft. vertical. The ditch is of the flat bottom type 24 ins. wide and 24 ins. deep, and has an outside slope of 1½ ft. horizontal to 1 ft. vertical.

With the exception of materials requiring a longitudinal haul, the bulk of the earth is moved by means of the ordinary blade grader. All cuts or fills requiring longitudinal movement of earth are first made by the use of wheel and slip scrapers, after which the ditches are cut by means of the blade grader, using for the bottom of the ditch a small machine, while the larger grader was used to prepare the embankment and to cut the outside slopes. In many instances outside slopes as high as 5 ft. have been cut with an ordinary blade grader.



VIEWS OF CONSTRUCTION OF GRAVEL ROADS IN WILSON COUNTY, KANSAS.
Left to Right:—Galion Gravel Screening and Loading Plant—Loading Trap—Forms Set for Spreading Gravel—Gravel Spread and Forms Removed.

Loading and Hauling

Before starting construction the county purchased a Galion loading and screening device, which has been used in the main for the loading of gravel. In some instances, where only a few teams were in use, and in the event more teams were on the work than could be supplied by the loader, wagons were loaded by means of a loading bridge.

The county purchased a truck, which is used for hauling gravel, but during a large part of the time the truck was out of commission on account of engine trouble, so that most of the hauling has been done by means of teams.

In order to care for the shortage of labor and teams the county engineer employed some unique methods for handling the hauling on this work. The farmers in the vicinity were informed that at any time when they had one or more days that their teams were not required for use on the farm they could report to the hauling foreman and haul for that length of time. In this manner the work was carried on even during the busiest farming season. During harvest, when the usual complaint is filed in Kansas that road work interferes with farm operations, the engineer published a notice that any farmer encountering a shortage of help could obtain assistance by applying to the engineer, who would release such men or teams as were needed to assist in the farm work. By this method hearty co-operation was secured and the most friendly relations exist between the county authorities and the farmers.

Placing of Gravel

In the usual gravel road construction little attention is given to the careful grading or measurement of the material deposited and as a rule an irregular surface is the result. But on this work one of the principal features is the care used in placing the gravel. Before any material is deposited grade stakes are set and side form boards placed, being firmly held by strong stakes and iron pins. Two by eight-in. planks are used for this purpose, giving a depth of gravel at the side of 8 ins. and a center depth of 6¼ ins. The material is spread by means of a blade grader and finally screeded to obtain a uniform depth. After the material has been dumped for a sufficient dis-

TABLE I—ACTUAL COST DATA OF COLEMAN GRAVEL ROAD PROJECT IN WILSON COUNTY, KANSAS, IN 1918-19

Grading		$ 507.41
2,572 cu. yds. gravel at 6½c		167.18
Loading 2,572 cu. yds. at 17c		440.25
2,061 cu. yds. hauled on unit price at 70c	$1,442.70	
135 cu. yds. hauled on time	91.40	
376 cu. yds. hauled by truck	227.60	
2,572 cu. yds. gravel hauled	$1,761.70	— 1,761.70
Leveling		240.31
Cement	$ 156.10	
Crushed rock	16.50	
Steel	38.89	
Sand	9.34	
Freight on sand	22.42	
Chatts	10.27	
Freight on chatts	38.60	
Miscellaneous	21.30	
Hauling bridge materials	61.46	
	$ 374.88	— 374.88
Superintendence		163.83
Engineering expense—		
Labor	$ 30.59	
Miscellaneous	15.00	
	$ 45.59	— 45.59
Total		$3,701.15

Length of project, 1⅜ miles.
Cost per mile, $2,691.75.

tance it is thoroughly harrowed by the use of a stiff tooth harrow and the form boards are removed, allowing traffic on the gravel to give it proper compaction.

Rolling

Rolling was first attempted, but it was found that the use of a roller on this kind of gravel gave very little better results at a much higher cost than to allow traffic to compact the gravel and to reshape it when it became scattered over the roadbed.

Finish

After the roadbed has been opened for traffic it is carefully dragged with the ordinary road drag after each rain and where appearances of pockets or depressions are found, a slight additional amount of material is sometimes added in order to furnish a uniformly smooth surface.

Approximately 19 miles of this work have been practically completed. A comparison of the estimated and actual cost of the Coleman project are shown in Table I and the detailed cost data of the same project in Table II. This work was constructed during 1918 and 1919. The county officials of Wilson county find it difficult to restrain more petitions being filed than can be handled for a number of years. All bridge and culvert work along these roads is being put in of first-class construction, and if in the future it is found that a gravel road is not satisfactory for the traffic, it will be a simple matter to prepare the sub-grade for one of the more permanent types of surface.

Assessments

After the work is completed and paid for the board of county commissioners apportion the cost of the improvement between the county, the township and the land in the benefit district as follows: The county pays 50 per cent. of the cost; the townships lying in the district pay 25 per cent. of the cost, each township paying in proportion to the area of the district lying therein, and the land in the benefit district pays 25 per cent. of the cost.

The board of county commissioners can pay the county's share out of any funds that they have on hand, or they can allow bonds to be issued for the period covered by the petition and levy a tax each year to pay the interest and principal on the bonds. The township's portion must be allowed to run as bonds, while the assessments against the land in the benefit district can either be paid in cash or by annual assessments for the payment of the principal and interest on bonds.

In assessing the benefits against the property the board of county commissioners take into consideration the benefit accruing to each piece of property with reference to its location with respect to the road, the increase in valuation that will be brought about and the service that will be rendered.

The work started in 1918 under the supervision of H. S. McFadden, county engineer, and is now in charge of C. P. Donald, county engineer.

DESIGN OF NEW SEWAGE TREATMENT WORKS AT FORT SHERIDAN (ILL.) GENERAL HOSPITAL NO. 28

By H. R. Abbott, President, The H. R. Abbott Co., Chamber of Commerce Bldg., Chicago, Ill.

As any connection with an existing sewerage system, for the disposal of the Fort Sheridan sewage was impracticable, it was the writer's recommendation that a complete sewage treatment plant be built inasmuch as the effluent from the plant would have to discharge into Lake Michigan. Accordingly, plans were prepared in the Sanitation Section of the Construction Division of the Army in Washington and the entire work executed in connection with the general construction of the entire Hospital project.

The treatment works consist of a diversion box, septic tank, dosing chamber, trickling filter, chlorinating and humus chamber, secondary settling tanks and sludge drying beds.

Diversion Box

As the new plant is immediately adjacent to the old one (built in 1912) provision was made for diverting a

TABLE II—COMPARISON OF ESTIMATED AND ACTUAL COST OF COLEMAN GRAVEL ROAD PROJECT IN WILSON COUNTY, KANSAS.

Item	Estimated Quantities	Unit Estimated Price	Estimated Cost	Actual Cost	Actual Quantity	Actual Cost per Unit
Excavation	4,079 cu. yds.		$ 417.48		4,079	
Shaping Subgrade	19,552 sq. yds.	.02	391.04	504.41		
Cost of Gravel for Roadway	2,536 cu. yds.	.06½	164.84	167.18	2,572	.06½
Loading Gravel	2,536 cu. yds.	.10	253.60	440.25	2,572	.17
Hauling Gravel	2,536 cu. yds.	.65	1,648.10	1,761.70	2,572	
Spreading and Rolling	13,041¾ sq. yds.	.05	652.09	‡240.31	13,041¾	
Plain Concrete in Culverts	47.29 cu. yds.	8.00	378.32			
				*374.88		
Reinforced Concrete in Culverts	23.35	12.00	280.20			
Eng'g and Superintendence			209.30	191.42		
Miscellaneous				15.00		
Overhead and Contingencies			219.76			
Rolling Omitted.		Total	$4,615.03	$3,701.15		

* Labor performed by prisoners.
‡ Rolling omitted.

portion of the flow to the old plant if occasion demanded. The 12 in. force main terminates in a concrete chamber 7 ft. 6 ins. x 10 ft. extending above ground and set at such elevation that a gravity flow is afforded to either the new or old plant. By opening the valves at the inlet ends of both plants, the flow would be automatically divided, at the ratio of 3 to 1 between the new and old plants respectively. It has not been necessary to use the old plant except for short periods when the new filter was rested.

Septic Tank

The tank is the standard construction division type, one story, multiple-compartment, horizontal flow, provided with baffles and cross-walls, or wiers, in such manner as to facilitate sedimentation and the withdrawal of the sludge. The entire structure is 43 ft. x 90 ft. and is covered with a wooden house equipped with shuttered windows and large louvers. All openings are screened. A dividing wall separates the tank into two units, each unit having four compartments. Pyramidal bottoms, sloping to a 3 x 3 ft. sump are provided for each compartment. These slopes are laid at an angle of 40 degrees from the horizontal. The sludge draw-off pipes terminate in this sump. A 4 in. water pipe line was laid connecting the sludge pipe lines at the tank with the Hospital supply system. This water pressure is desirable in flushing the sludge pipes after sludge is drawn, hosing down scum and agitating the sludge in the bottom of the hoppers for short periods by applying pressure through the sludge pipes. The total depth from the flow line to the bottom of the sump is 18 ft. and from the flow line to the top of the hopper slope is 9 ft.

The total capacity of the tank, including the sludge hoppers is 290,000 gals. and the capacity of the hoppers only, 66,000 gals.; this is equivalent to a per capita capacity of 41 gals. gross and for the hoppers only, 9 gals., based on a 7,000 population. The estimated flow of sewage in designing the plant was as follows:

4,800 patients at 150 gals.	720,000 gals.
2,200 others at 100 gals.	22,000 gals.
	940,000 gals.

Average for all 134 gals.

On this basis the tank would have an average detention period of about six hours. However, as this maximum estimated population was never reached by 25% the detention period was increased a corresponding amount, as the actual water consumption was very close to that estimated.

Ground was broken on Nov. 10, 1918, and first sewage turned into the tank March 27, 1919. No septic action or gasification could be observed until July 16th, a period of nearly 4 months, although the tank had been seeded with ripened sludge from the old plant. This delay in the tank starting up was probably due, in part, at least, to the large quantity of disinfectants used in the hospital and discharged into the sewer. Upon investigation it was found that Dakins' solution, lysol, cresol, carbolic acid and other disinfecting chemicals were used extensively.

The tank is designed on the simplest possible lines, in order to facilitate construction and reduce the cost to a minimum. On account of the shallow depth, the time required for construction, as well as the cost, is a great deal less than that required for Imhoff tanks. Another feature is the maximum effect in sedimentation, thus offering protection to the filter where an excessive quantity of grease is carried in the sewage. The process of digestion of the retained organic matter in a well "ripened" tank has been described "as a series of stages. The products of decomposition differ considerably in the different compartments, the effluent from the last compartment being much superior to that in the first compartment."

At the outlet end an inclined baffle is placed, so arranged as to prevent the "carrying over" of the suspended matter, a similar baffle is placed in the first compartment at the inlet in order to retain the grease and afford an opportunity for skimming. Sludge is removed from the several compartments by draw-off pipes leading to the drying beds, or sludge can be transferred from one compartment to another by drawing down the liquid by separate draw-off valves and obtaining the necessary head. Sounding boards 15 ins. square with small pigs of lead attached were suspended by pulleys over each compartment for determining the depth of sludge.

Siphon Chamber

The effluent from both units of the tank flow to a trough 24 ins. wide and 10 ft. long, from which the discharge is over a sheet iron wier and into a siphon chamber. The trough is housed in and midway between the tank and the siphon a 3/16-in. triangular mesh screen is placed as a protection to the filter. An extra screen is provided and is placed before the one requiring cleaning is withdrawn. It was found that one cleaning per day was sufficient for this screen. A Sanborn 24 hour clock, water level recording gauge is placed in this gallery. A flow diagram was worked out and chart posted for the use of the attendant. This apparatus is also an excellent check on the pumping operations at the Sewage Pumping Station as any stopping of the pumps for a considerable period, or bypassing of this raw sewage into the lake at that point would be indicated on the recording chart.

The siphon chamber is pyramidal, 12 x 12 ft. at the top and 4 x 4 ft. at the bottom, equipped with a Miller 6 in. automatic siphon having a 4 ft. 6 in. draft and a maximum head on the sprinkler nozzles of 7 ft. The capacity of the chamber is 2,300 gals., and at the average flow of 700 G. P. M. the filter is dosed every 3 1-3 minutes. When the filter was first started up it was found that air was being carried into the drum of the siphon by the action of the liquid spilling over the wier and falling near the bottom of the drum. As this prevented the proper operation of the filter, wooden baffles were placed across the chamber at the bottom of the drum, concrete flared away at the sides of the wier opening and certain adjustments made on the siphon vent tubes. No trouble was experienced in the operation after these changes had been made. The siphon chamber is housed and is directly connected with the gallery containing the recording apparatus.

Trickling Filter

This filter is 106 x 205 ft. or ½ acre in area. Filter-

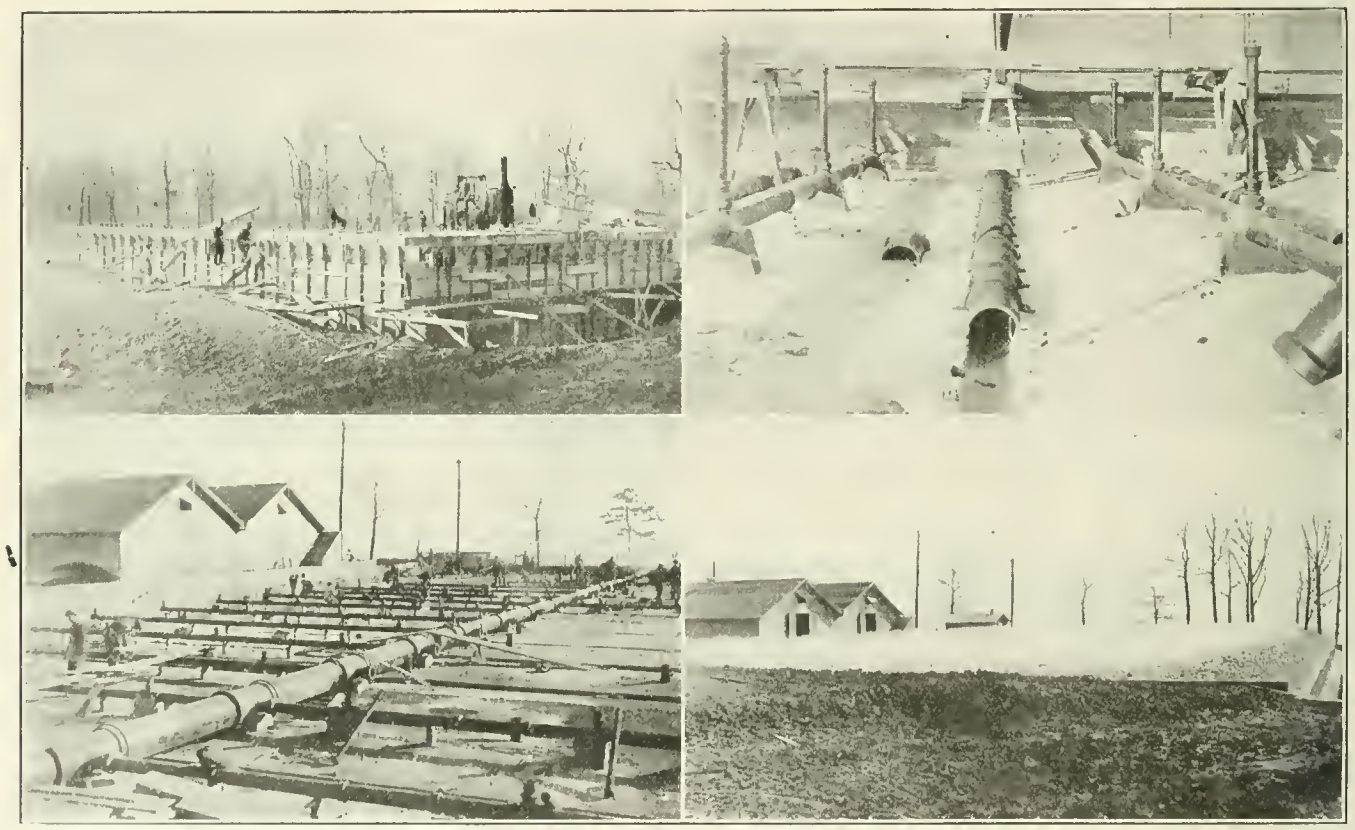
ing medium is Illinois limestone and the specifications called for sizes ranging from 1 to 3 ins. Trouble was experienced in obtaining clean stone and a considerable quantity had a large percent of screenings and stone dust. This dust gradually worked down to the gutters, after the filter was put in operation, and finally found its way to the humus chamber. This necessitated frequent opening of the blow-off valve in this chamber, during a period of about two months, after which the dust finally disappeared. The depth of stone is 5 ft. and is deposited on an undulating concrete floor, the lateral distributing pipes being placed at the summits and the gutters in the depressions. The main distributor bisects the bed on the long axis, being 18 ins. in diameter at the siphon and stepping down gradually to 10 ins. at the end. From this distributor 6 in. laterals carry the effluent to 136 is placed 10 in. split tile supported by broken pieces of tile, leaving a clear opening of ¾ in. between the tile and the filter floor.

The filter is designed on simple lines, omitting several of the features heretofore considered more or less essential in municipal practice.

Chlorinating and Humus Chamber

The effluent from the trickling filter flows to a chlorinating chamber, having a capacity of 8,600 gals. above the hopper. This chamber is 13 x 17 ft. and covered with a house. A sealed partition divides this house in half, one portion containing the chlorinating apparatus, reserve chlorine tanks and platform scales. The tank in service is kept standing on these scales and the amount of chlorine used is determined daily as a check on the apparatus.

A Wallace & Tiernan, manual control, dry feed ap-



VIEWS OF SEWAGE TREATMENT PLANT AT FORT SHERIDAN (ILL.). GENERAL HOSPITAL NO. 28.

Top Row: Septic Tank with forms and steel in place for placing concrete—Shows underdrains in filter and risers in place; also shows movable trestle for dumping the crushed stone on the bed. Bottom Row: Main distributor and lateral pipes—Sprinkling Filter in operation.

3 in. risers, four on either side of the distributor. The risers are fitted with 13-16 in. Worcester type of nozzle.

The arrangement of the spray nozzle is rectangular and spacing is 11 ft. 6 ins. The nozzles are on an inclined plane approximately equal to the hydraulic grade line at the average rate of discharge and the distributing pipes and under drains are parallel to this plane. A 2 in. bleeder line is connected to the distribution system for draining it if occasion requires. Wherever possible concrete retaining walls were omitted, terminating the filtering material with steep slopes. The under drains are 10 ins. in diameter, the invert being an integral part of the concrete floor and over this

paratus was installed and effluent is dosed at the rate of 2½ parts per million. The other portion of the house is used for the attendant's quarters and facilities were provided for making simple tests of the sewage effluent. Conical Imhoff glasses were installed for determining the percentage of settleable solids; also bottles for making the Methylene blue tests for relative stability. Flow charts, log book, printed forms for records, telephone and a set of operating rules were provided.

Secondary Settling Tank

The effluent flows from the chlorinating chamber

(Continued on page 216)

"What did the teamster see
In old days, driving his heavy loads
From farm to town, over hills and prairies?"

A Vision of BETTER ROADS

WHAT did the teamster see
In old days, driving his heavy loads
From farm to town, over hills and prairies,
Through mud and flood and storm and washout,
By wood-roads and highroads and the great
National Highways from State to State,
His strong horses straining and sweating through
dust or mire—
What did that hardy teamster see
On those long, hard roads behind his laboring team?

Across the years he saw a vision,
Prophetic, happy, haunting and inspired—
A Vision of Better Roads in the days that were to be.
He saw broad, smooth highroads running everywhere
in a vast network over the country,
Roads without dust or mud or weariness or the
constant labor of repair,
Roads pleasant and swift to travel,
Roads clean and safe and paved,
Leading to great cities and friends and business and
on adventurous, delightful journeys,
All over this broad, beautiful land.
He saw himself and his wife going and
returning over these fair highways,
Making trips to town for shopping or pleasure;
He saw his boys and girls going to better schools,
and better satisfied with their home;
He saw an end to dreariness and monotony
and isolation;
He saw his produce carried quickly to market, and
anything he needed brought as quickly
back to his own door;
He saw happiness, comfort and prosperity in that
Vision of Better Roads—
The vision of things which his energy and
resourcefulness and courage are today
bringing to pass.

IT was "A Vision of Better Roads" that brought forth Tarvia—which has given smooth, dustless, mudless, waterproof highways to thousands of communities all over this vast land. If you are interested in good highways, write at once to our nearest office for booklets and further information.

Tarvia
Preserves Roads
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(Continued from page 214)

through a 15 in. running trap to two circular settling tanks, each 18 ft. in diameter with conical bottoms. These tanks were part of the old plant and the new layout was so arranged that they could be used as secondary tanks. The combined capacity of these tanks and the chlorinating chamber is 40,000 gals., affording a detention period of about one hour at the average flow. These tanks are provided with wooden trough wiers at the flow line and effluent passes through these to a collecting manhole, thence to a 10 in. discharge pipe extending down the bluff and carried out into the lake about 200 ft. and resting on piles. Sludge draw-off pipes lead from the conical bottoms of these tanks and connect with the same outlet.

Sludge Drying Beds

Sludge drying beds, 40 x 100 ft. were built, the bed being divided into four equal pockets. Concrete walls enclose the beds and form the dividing walls of the pockets. The area per capita is 0.6 sq. ft. The filtering material consists of 10 ins. of coarse rock, 5 ins. of gravel and 3 ins. of coarse sand, making a total of 18 ins. The beds are under drained with 6 in. vitrified tile laid with open joints and the liquid drains to the chlorinating chamber. Diversion boxes are provided for diverting the flow of sludge from the tank to any pocket. The sludge pipes are carried well inside the bed and are elevated about 14 ins. above the top of the filtering material; the discharge from the pipe drops onto concrete aprons in order to avoid erosion of the sand in the bed.

General

Daily tests with the Imhoff glasses showed a removal of settleable solid of 95 to 99% an average of about 98%. Relative stability of the filter effluent ranges from 80 to 99% on tests made in accordance with standard methods of water analysis.

The plant was constructed by the Sumner Sollitt Co., General Contractors for the entire Hospital project. The design is by Major L. S. Doten, Sanitary Engineer of the Construction Division. Work was carried out under the direction of the writer as Supervising Engineer.

The foregoing is extracted from a paper by Mr. Abbott before the annual convention of the Illinois Society of Engineers.

ALBUQUERQUE, NEW MEXICO, COVERS ALL MUNICIPAL EMPLOYEES WITH GROUP LIFE INSURANCE

The city of Albuquerque, N. M., announces an innovation in the way of municipal management in the form of equitable life insurance for all employes of the city from the city judge to the garbage collectors. The program includes all employes of the Board of Education and the teachers in the city schools.

James N. Gladding, city manager, entered into the contract for the city and Mr. E. Hickey acted for the Board of Education. The insurance is given without cost of any kind to the employes, and its benefits are in addition to employes' compensation. About 125 persons will be benefited by this unique program. The plan extends to all employes who have been in service one year, at which time an insurance certificate in the Equitable Life Assurance Society will be presented in the amount of $500. At the end of each additional year of service an additional certificate for $100 is presented. Among the city employes this year to year increase in the amount of the insurance continues successively until a maximum of $1,800 is reached. In the Board of Education there is a maximum of $2,000. In both instances the plan is made retroactive as to length of service, thus giving all employes credit for service rendered. Among the employes on the city pay-roll are 11 mechanics, 3 laborers and 11 clerks. There are 8 policemen, 17 firemen, the city judge, the city doctor, the city chemist and the city attorney.

Group insurance was introduced by the Equitable some 10 years ago. Under this form of insurance all the employes of an institution are covered under a blanket policy, without medical examination and without regard to the ages of the employes. The plan has had a very remarkable growth and it is estimated that there are today one million industrial workers protected by this form of insurance.

The action of the Albuquerque authorities is the first instance of such a program being extended to all the employes of a municipality, but it has for some years been in force in such institutions as the Union Pacific System, the Standard Oil Company, Montgomery, Ward & Co., and the American Sugar Refineries.

Group insurance is not confined, however, to large institutions, but concerns having fifty employes and up may take out such policies. The action of the Albuquerque authorities has attracted the attention of other cities and towns, and it may be expected that other communities will shortly be following suit.

KEEP THE CEMENT SACKS AT WORK

One empty sack at the cement mill is worth any number of them lying idle in dealers' or users' hands all over the country, in so far as shipment of cement is concerned. Like many other kinds of cotton goods, cement sacks are scarce. If every idle cement sack in the country were returned to the plant which sent it out, there would be considerable relief of the present shortage both of cement and sacks.

Besides, cement sacks cost cement users money—money which is not working for them as long as they keep the sacks in their possession and thus make it impossible for the manufacturer to buy them back.

This condition is simply another one of those seemingly trifling items of neglect that in its own way is contributing to keeping the wheels of industry from moving as regularly and as smoothly as all would like.

WATER WORKS SECTION

SOME PROBLEMS ENCOUNTERED IN THE REBUILDING OF WATER WORKS

By Charles Brossman, Consulting Engineer, Merchants Bank Bldg., Indianapolis, Ind.

The rebuilding of water works may involve a multitude of problems, but it is of especial interest as related to some of the smaller plants, as these town have a harder time to make ends meet as compared with the larger city, said Mr. Brossman, in address the Indiana Sanitary and Water Supply Association recently.

The more populous town, if it has the money, usually requires equipment of such size that it will operate economically, provided good engineering principles are followed, and in many such cases the question of plant economy is likely to become principally a boiler room question, because this is usually where the large loss occurs. By this I mean that assuming you have a good high duty pump, the duty will not change within a short period if the pump receives proper care, but the best boiler plant in the world, even if new, can be made to change its efficiency 10, 15 or 20 per cent. simply by improper firing, draft conditions or other matters, and this change may take place from hour to hour.

Reducing Fuel and Labor Cost

The small water utility is a harder problem than the larger installation. If such a plant be steam operated in a town of from 2,000 to 3,000 the boiler load usually is very light, the firing periods infrequent, and many times at from 20 to 30 minute intervals, and usually you will find the old compound duplex pumps or even the simple pumps running non-condensing.

Here will be found two large items: namely, coal and labor cost, and with the increased price of both within the past few years it becomes necessary to cut out all the labor possible and decrease the power cost to the minimum. I will illustrate how this has been done in several cases and what the results have been. In order that this may not be a theoretical comparison, I will take as the first illustration the town of Delphi, Indiana. Before being called on this work many different schemes had been advanced to cut the operating cost, such as installing a large storage tank of 150,000 gals. capacity and to pump during an 8-hour period. Various schemes to pump electrically were also recommended.

Solving the Problem at Delphi Ind.

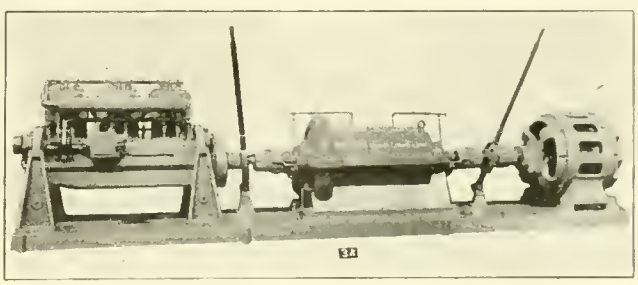
In the first place this tank alone would have cost 50 per cent. more than the actual cost of their final electric equipment, and the plant would have cost almost as much to operate as under the old method.

Among other methods considered were installing a new high duty steam pump, pumping by different types of electrical equipment, pumping with present equipment and installing a large elevated tank, cutting down the pumping time.

The original cost of operation with the old steam pumps was $4,827.50 per year. Using electric driven pumps, making the plant automatic and cutting out all of the labor, it was estimated that the entire yearly cost would be less than $2,000, or a saving shown of $2,800 a year, and with interest and depreciation considered, a possible saving of a little under $2,000 per year.

Factors to Consider

It is very important in these smaller installations to get proper estimates on the amount of water being pumped, as if this is not done and the consumption exceeds the estimate, there is likely to be disappointment on the cost of operation. It is necessary that the designer exercise good judgment and obtain all possible information on this subject, not only from the point of proper pumping



VIEW OF 6-IN. 6-STAGE MIDWEST DIFFUSER RESERVE PUMP FOR FIRE OR DOMESTIC SERVICE OF CITY OF DELPHI, INDIANA, DRIVEN BY 75-H.P. LINCOLN MOTOR OR 75-H.P. WISCONSIN GASOLINE ENGINE. PUMP DELIVERS 800 GALS. PER MINUTE AGAINST 231 FT. HEAD.

capacity, but also in order to get the most efficient pump, as on centrifugal installations if there is not the proper relation between capacity and consumption there is considerable loss in power. These matters should all be gone into very carefully.

Another very important item is the question of fire service. Any electric transmission line is subject to break-downs or mishaps for short periods, or the power plant may be out, and in such a case with electric drive the town will be left without water, except for such capacity as is available. Under the Delphi conditions this tank was only good for about 20,000 to 25,000 effective storage when full, and it must be remembered that the power might go off when the tank was at the low point, and it was therefore necessary that some reserve power be provided. In this case oil and gasoline engines were considered, and it was found that the gasoline engine fulfilled the requirements to better advantage than oil, while more expensive to operate it was quicker to start and was much cheaper and would only be used occasionally.

Selecting Reserve Power Units

A word of caution should be given in the selection of

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such reserve power. It is better to pay a little more and get a slower speed engine. In some instances I know of engines operating for a number of days without an interruption, and if you have a bad fire you want something that will stand up to the work.

Owing to the current at Delphi coming from the electric railway this meant 25 cycle current and meant either a 1,500 speed or 750. In order to pump the amount of water desired, about 800 gals. per minute at 100-lbs. pressure, this requires a pretty sturdy engine. To run an engine of this size at the rate of 1,500 revolutions did not appeal to the writer at all. Our specifications therefore called for a speed of 750, and this required a 6-stage centrifugal pump, due to the low speed, but we believe the difference has been worth while. Of course, with 60-cycle current our speed could have been 1,200, and we believe this is getting close to the limit for good permanent operation as far as the engine is concerned.

New Pumping Equipment at Delphi

The plant at Delphi is arranged with two 400-gal. Midwest 2-stage diffusor pumps connected to 30 h.p. Lincoln motors, speed 1,440 r.p.m. pumping against about 60-lbs. pressure. These pumps are not connected in series, but are used for ordinary fires. The reserve unit consists of a Midwest 6-stage diffusor pump, good for 100 lbs. pressure at 750 revolutions. This pump has a 75 h.p. Lincoln motor connected with jaw clutch on one end, and on the other end for reserve power a 6 cylinder 5¾x7-in. Wisconsin gasoline motor complete with electric starter. In case of a break-down the gasoline engine can be operated either for fire pressure, in which case it can be speeded up if necessary, or it can be operated at a lower speed and used for domestic pressure in case the power is off. This engine is turned over about once a week for a short time. The generator for charging the battery is connected to one of the domestic pumps, so that the battery is always kept well charged, ready for starting.

Changing to Electric Service Saves Money

The entire cost of this work installed was about $11,000. By it, all labor has been dispensed with, and this amounted to $1,680 before the plant was started. The 1918 cost of coal amounted to almost $4,000 per year, or, to be conservative, for the year 1917 it was about $3,100; these two items of labor and fuel amounting to approximately $4,800. The actual cost of current to operate these pumps the first few months was about $40 per month. This was on the old off-peak 2-ct. rate, but after contracts had been let for the plant, the matter of rates was brought up by the Power Company before the Public Service Commission, and after adjustment the average cost per month will now amount to about $75, or about what they used to pay one fireman. This is the entire total operating cost of this plant, or about $900 per year. Therefore, the present operating cost is to the old operating cost as $900 is to $4,800, or there is almost $4,000 a year difference. Of course, to this must be added the interest and depreciation, which would amount to approximately $900 a year. It will therefore be seen that the changing to electric service has been a very good investment for the city of Delphi.

The Rate Question

On the matter of rates, this should be very carefully considered, as where a number of different published rates are available, the one that apparently seems to be the lowest does not always work out so. It has been the intention of the city to take advantage of the straight off-peak rates, but when the matter of rate readjustment came up the writer recommended the rate as under the demand charge, as this would save any trouble about operating under the off-peak.

In all the above calculations it should be remembered that a superintendent of water works is required and that he is still retained, and what slight attention the present pumps needs, such as oiling, is done by the superintendent but the plant requires very little attention.

Plant at Rochester, Ind.

Another plant, but slightly differently arranged, is the one designed by the writer for Rochester, Ind. This consists of two 500-g.p.m. DeLaval pumps and 40-h.p. G. E. motors and one 1,000-g.p.m. DeLaval pump and 60-h.p. motor. These pumps are arranged so that they can all be operated for domestic consumption, giving a total capacity of 2,000 g.p.m. This gives standpipe pressure and can also be used for fires, where pressure not over 50 lbs. is suitable. In case high pressure is required the two 500-gal. pumps are operated in series with the 1,000-gal. pump, giving 1,000 gals. at about 100 lbs. pressure. In this plant it was necessary to do something to replace the old machinery. The local power company made a proposition to pump all the water for $3,600 per year, and attend to the plant, and this contract is now in effect. The former cost of operation with the steam pumps was about $4,800 per year. This plant has as reserve its old steam pump and boiler. It would have been necessary for the city to have installed some kind of new equipment, and with the proposition made by the local power company the electric drive was thought more advisable. While the steam reserve does not allow a very quick starting up in case of accident with the transmission lines, in this case the possibility of power being out was small, as it is only a short distance to the local power plant, and any break in the transmission could speedily be located and repaired, and it was thought that the supply in the standpipe would be sufficient to tide over such periods.

Plant at Van Buren, Ind.

Another small water works plant in a town having a population of only 1,200 would be of interest, and mention is made of the town of Van Buren, which purchases current at 2½ cts. per k.w.h. for pumping purposes. Two triplex pumps were installed, each of 125 g.p.m. and geared to a 10-h.p. slip-ring motor. These pumps are both controlled by a special design of automatic control, having two regulators for each outfit. The pumps discharge into the main and are connected to a pressure tank of 5 ft. diameter by 20 ft. long. This system has about 9,000 ft. of mains, 18 fire hydrants, and the entire plant was installed for $9,500. The plant is operated by the town marshal, who is also the street commissioner. His water works duties consist of oiling machinery, and $20 per month of his salary is charged against the water plant. Power averages $15 per month, and the entire cost of operation, including interest at 5 per cent. and depreciation at 1½ per cent. is estimated at $1,085 per year. This shows that such a plant can be operated on a paying basis. The entire operation of the plant has been satisfacory in every way and the town is greatly pleased with its success.

COMPETITION BETWEEN MUNICIPALLY AND PRIVATELY OWNED WATER WORKS AT LIVINGSTON, MONT.

By Robert E. McDonnell, of Burns & McDonnell, Consulting Engineers, Interstate Bldg., Kansas City, Mo.

Livingston, Mont., with a population of about 8,000, located on the Yellowstone River, contended that its franchise to the privately owned water company expired in 1911, and, looking toward municipal ownership, the city had an appraisal made of the water works property and appointed its representative to confer with a representative of the water company with a view to arriving at negotiations towards purchase.

Private Company refuses to Negotiate

The engineers found the estimated cost of reproducing the property, $165,662. A further estimate was made of the cost of building a modern plant, new in every respect, which was $225,000. Every effort was made by the city officials to encourage negotiations towards purchase, but the company declined to confer with the city representative and scorned all efforts to reach any agreement, leaving the city with the only alternative of installing its own plant, in order that the city might procure proper fire service and filtered water, which the company declined to furnish.

The privately owned company's source of supply was the Yellowstone River, which at times is subject to pollution and in the spring months is very heavy in sediment. The State Board of Health made sanitary surveys of the Yellowstone River and recommended filtration, with chlorination, in order to procure safe water. The company declined to heed these suggestions, and the city, as a last resort, was compelled to install its own plant, in order to be sure of an abundance of good, pure water. But acting under the advice of engineers and rather than enter in a competitive business, the officials of Livingston renewed efforts to purchase the plant, even offering considerably more for the plant than an entire new plant could be built for, but without success.

The Municipal Plant

Following these failures to purchase the existing plant, the city voted $260,000 bonds for a complete new plant, which provided for a modern filtration system, using the Yellowstone River as a source of supply, but locating the plant above the surface drainage of the city of Livingston. One of the strong reasons for building the municipal plant was the necessity of procuring filtered water and a plant so located that the surface drainage of Livingston would not enter the river above the intake.

Comparison of the Two Systems

Although the preliminary steps were taken in 1911, it was approximately nine years later before the plant was placed in operation. Injunction suits against the bond election, against the selling of the bonds, against letting contracts, and other steps, were constantly brought by the company, entailing endless litigation, but eventually the city plant was placed in operation. Now, after one year's operation, it may be of some interest to note a comparison of the two plants.

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Private Plant	*Municipal Plant*
Number of miles of mains, 10.5.	Number of miles of mains, 14.55.
Number of fire hydrants, 96.	Number of fire hydrants, 138.
Storage reservoir capacity, 415,000 gals.	Storage reservoir capacity, 1,000,000 gals.
Average domestic pressure, 35 to 45 lbs.	Average domestic pressure, 70 lbs.
Water used without filtration.	Water filtered, modern mechanical filters.
Number of water services before municipal plant operated, 1,330.	
Number of services one year after municipal plant began operation, 300.	Number of water services at beginning of operation of municipal, 0.
	Number of services one year after beginning of operation of municipal plant, 1,180.
Total appraised value, $165,662.	Total final construction cost, $255,538.
Report of water tests shows doubtful quality and high turbidity.	Report of water tests shows negative, with safe water for all domestic uses.

It will be seen from the above comparison what patronage will be given to the average municipal plant placed in operation under similar conditions. It is estimated that the gross income for the coming year will be approximately $35,000, and the general public express entire satisfaction and approval of the operation of the municipal plant. The property owners have enjoyed a large reduction in their fire insurance rates, but the phenomenal success of the municipal plant is largely attributed to the furnishing by the municipality of a supply of pure, clean, filtered water at a pressure that is satisfactory for all domestic requirements.

The privately owned plant continues to operate on part time with a reduced force of employes. Some of the friends of the private company have expressed the opinion that the privately owned plant will cease to operate before the close of the year.

The above comparisons are not offered as any inducement or encouragement for cities to build or operate competing plants. This course was advised against at Livingston and every effort was made by the municipality to avoid a competing plant, but the city being forced into this procedure, it is of interest to see the outcome of the establishing of a competing municipal plant.

Much of the success of the municipal plant is due to the energetic activities of J. A. Cortese, the superintendent of the water committee, consisting of J. W. Fryer, A. J. Huffer, and its chairman, H. S. Masters. Each year the city of Livingston re-elects officials in thorough sympathy with municipal ownership, and the present Mayor, Lewis Terwilliger, shares these views.

The engineers representing the city in the appraisal and in making plans and estimates for the new plant and its supervision to completion were Burns & McDonnell, Consulting Engineers, Interstate Building, Kansas City, Missouri.

RATIONAL METHOD OF DEVELOPING A SHALLOW GROUND WATER SUPPLY

By W. D. P. Warren of Miller, Holbrook, Warren & Co., Civil Engineers, Decatur, Ill.

One of the most interesting and perplexing problems which an engineer is called upon to solve is that of developing a supply of water from shallow-ground wells. To the public the big impounding reservoir, with a "visible supply of water," is a real engineering accomplishment. However, at times, it may be exactly otherwise.

The writer has given some study to the development of both impounded and well supplies and fully appreciates the necessity of the impounding reservoir under certain conditions. The plan of developing water from wells is an extremely old one, and yet one on which the best technical advice should be obtained before final plans for developing an impounding reservoir are adopted.

A few years ago the writer was called upon by the officials of Witt, Ill., to assist them in developing a supply of water, and the difficulties encountered in the development of this supply led to a somewhat more extended study of well supplies than might otherwise have been thought necessary. In the development of the supply at Witt, valuable support was given by the Mayor, Dr. Charles Lockhart, who, being a professional man, realized the value of professional services in this matter, and gave every assistance possible.

A Typical Problem

Witt, Ill., is a city of 3,000 population, and inasmuch as the conditions encountered there are more or less typical, it will serve to illustrate the method of developing water from shallow-ground wells, to which it is desired to call attention.

The first information given the writer at Witt was that the City Council as a whole, wanted a visible supply of water, also that there was no chance for a well supply, as both mines in that vicinity were dry, and further that the only wells near the city were shallow and showed no promise of an adequate quantity.

Further investigation disclosed the fact that the Engineers for the State Water Survey had been over the ground several years previously and had made a brief, although valuable report.

We quote below an extract from the Letter of Transmittal of Mr. Paul Hansen, Engineer, and are pleased to call attention to the fact that in this letter he pointed a way to the proper solution. The date of this letter is June 4, 1913:

"At present there are no available data which would point to a successful water supply, but it would seem worth while to prospect by means of test wells, especially toward the northeastward, at a distance of several miles, where the city of Nokomis has been very successful in securing an abundant supply of water from wells penetrating sand and gravel in the drift at a depth of about 40 feet."

Quite contrary to the advice of the State Water Survey, a number of the officials determined to undertake the development of an impounding reservoir, the thought being that a well supply was too uncertain. Under these circumstances the investigation of a surface supply was begun.

Impounded Supply

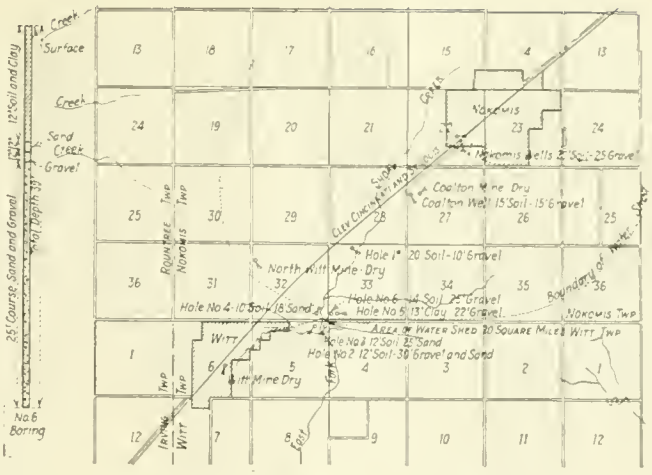
Surveys were made on a number of sites considered feasible, but as the territory about Witt is comparatively flat or rolling, no site was found nearer than 4½ miles from the city. The drainage area here was considered sufficient, and this project appeared feasible, although a filter plant would have been required for the treatment of the water to render it suitable for domestic use.

The surveys and estimates on the various sites were shown in a report covering the investigations for the city.

The estimated cost of the supply from the impounding reservoir, delivered to the city, and not including distribution system, was about $125,000.00. This amount was greatly in excess of any figures the officials had in mind for such a supply, and it was no doubt due in a measure to this fact that they were led to adopt the recommendations contained in the report that a full study be made of a possible well supply before deciding to adopt any plan for an impounding reservoir.

Investigation of Well Supply

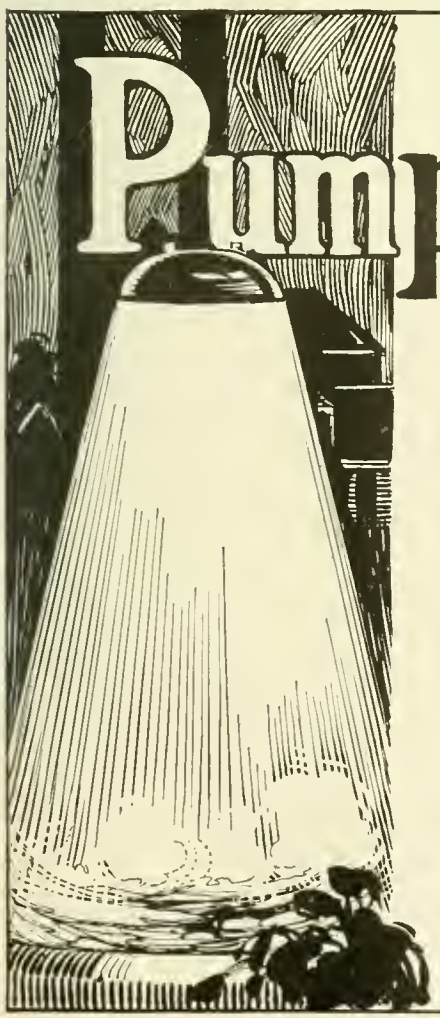
In undertaking to develop a well supply the writer was limited in the beginning by a resolution of the City Council to the effect that not to exceed six wells should be drilled. Several days spent on the ground disclosed the information that the mine in the south part of the city was dry, also that the mine about one mile north of the city was dry, and that the closest known well proposition was at Nokomis, about 4½ miles northeast of Witt. A visit was therefore made to Nokomis and valuable information secured from the officials in charge of the plant at that place. The Nokomis supply is from six 6-in. wells, about 40 ft. deep, the wells being driven into the drift and passing through 20 ft. of soil and clay and 25 ft. of coarse water bearing sand and gravel. The gravel appeared to be of a grey or bluish color with little silt or clay in it, being of similar color and character to the material from which the supply at Bloomington, Illinois, is secured.



DATA DERIVED FROM GROUND WATER SURVEY IN VICINITY OF WITT AND NOKOMIS, ILL.

At this time it was considered that the supply at Nokomis, being in a wide flat valley, might be found further down, in a general southwesterly direction toward Witt, but east of the closest point of the city limits by about 3,000 ft.

This theory that the gravel deposit might continue down the valley was borne out in a way by information that in sinking a new mine southwest of Nokomis, con-



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siderable water had been encountered and it had been found necessary to change the location of the proposed mine to a point somewhat further east from the general lines of the valley. A conference was held with Mr. Sjoblom, Acting Chief Engineer of the Department of Public Health at that time, and much credit is due him for his excellent advice in this matter.

The statement of Mr. Sjoblom was to the effect that if it was necessary to go 4½ miles for a supply from an impounding reservoir and then treat the supply, it would be much more practicable to develop a well supply, even if necessary to go somewhat beyond the 4½ mile limit. In other words, a real tangible starting point was established. Inasmuch as the supply at Nokomis had been very thoroughly tested over a period of years and was known to be adequate, it was therefore seen that Witt could at once get a well supply from Nokomis, only 4½ miles distant, and thereby effect a very substantial saving over the method of an impounding reservoir.

Drilling

The location chosen for putting down hole number 1, was in about the center of the valley, two miles southwest of Nokomis and roughly in line with the Nokomis wells and the mine test hole one mile southwest of Nokomis, as above referred to. At a depth of 20 ft. a very excellent quality of water bearing sand and gravel was encountered and was found to be 10 ft. in depth, giving a total depth of 30 ft. for the well. The well driller called attention to the ease with which the well casing and drill seemed to go through this gravel deposit and stated that the flow of the water appeared to be extremely "free." This gravel was of a greyish or bluish color.

Hole number 1 indicated an adequate supply of water for Witt at a distance of only about two miles from the city, however, it was thought that the deposit would probably be found down the valley and closer to the city limits.

In selecting a site for hole number 2, it was decided to choose a point on the west edge of the valley, and in so doing, the hole was located within a short distance of a little branch entering the valley, and as a result considerable silt and clay were found in the sand, probably due to action of the currents caused by this small branch entering the valley proper. Furthermore, the sand did not run as coarse as in hole number 1 and was of a yellowish color. It was concluded that this hole was on the western edge of the deposit, for it was very similar to holes put down about that time at the mine located one mile south of Nokomis above referred to, which was known to be east of the main gravel deposit.

Hole number 3 was about 200 ft. east of number 2, but showed much fine sand; also holes number 4 and 5, which were about 500 feet north of holes number 2 and 3, showed more or less fine sand. However, hole number 5 showed better sand and, as it lay more nearly in the center of the valley, it was concluded that further drilling would locate the coarse material where the flow through the gravel would be more "free."

Considerable pressure was brought to bear at this time to induce the city officials to stop such "useless waste of money" in drilling holes out in the country and to either put down some holes in Witt, where the city owned several vacant lots, or abandon the drilling entirely.

This attitude at Witt was anticipated and cleared up only by a careful statement of the methods being followed in the development of this supply.

It is proposed in this article to refer to the method of developing the supply from shallow wells as the Rational Method, for as in the case of sewer design by the Rational Method, opportunity is given for exercise of judgment and experience, as well as for the application of fundamental engineering principles.

Rational Method

In the study of the problem at Witt careful search was made of available works on water supply from wells, and only a very few authors were found who gave a clear and reasonable method of procedure for the development of a shallow-ground water supply.

Hubbard and Kiersted in their book, "Water Works Management and Maintenance," have set down in simple language the following fundamental considerations which govern:

"No more water can be continuously taken out of the ground than goes into it.

The yield of the ground-water is dependent upon the character and extent of the catchment area and depth of the saturated water-bearing material.

"The velocity of flow of ground-water depends upon the character of material through which it must pass in gravitating from a higher to a lower level.

"The stability of the ground-water supply depends upon the three considerations above stated as well as upon available ground storage at the point selected for developing the water-supply."

From a study of the accompanying sketch it is seen that the area of the water shed northeast of Witt is 20 square miles, a sufficient catchment from which to secure water for a much larger city.

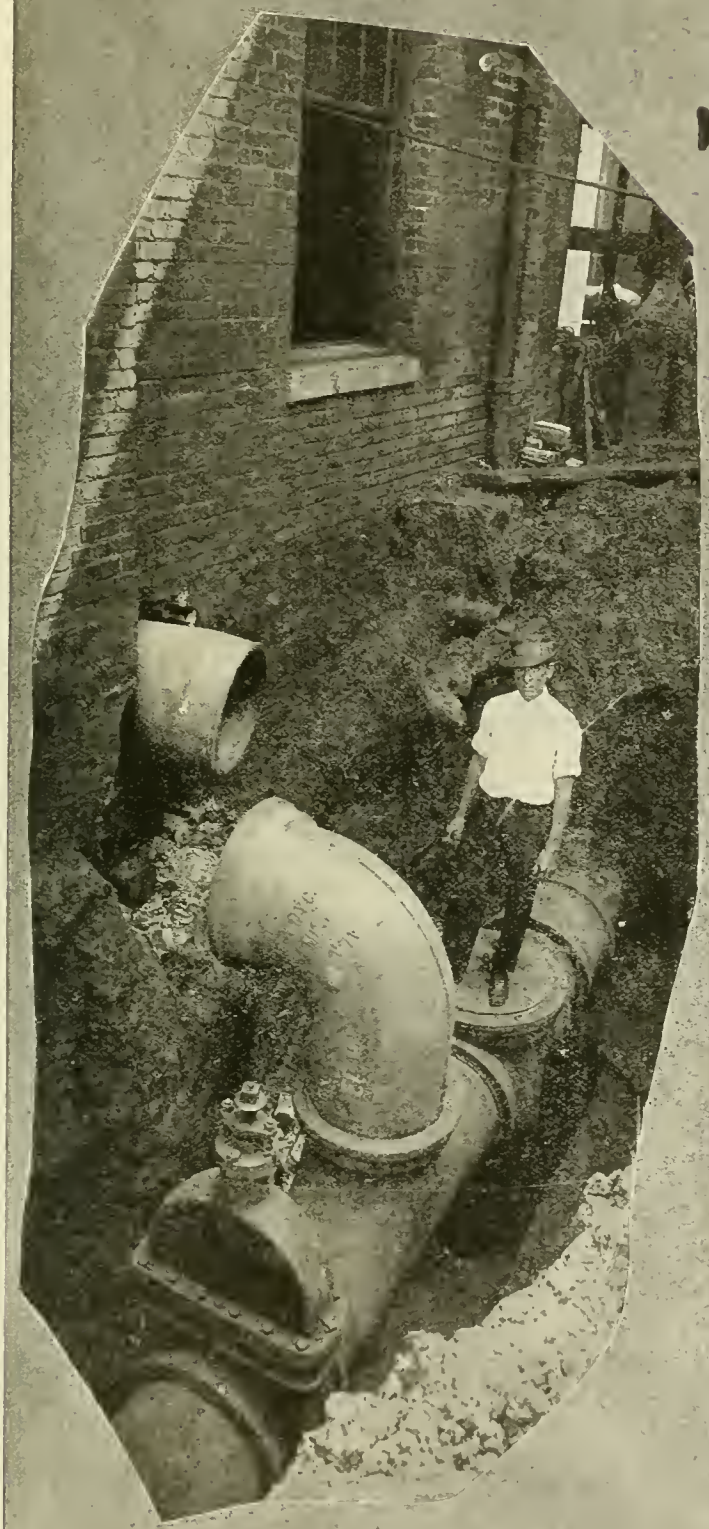
Evidently then we have a much greater promise of an adequate supply from this valley than from any point nearer the city with a less catchment area, assuming that we expect to develop a shallow-ground supply.

Furthermore, we see that the yield is dependent upon the depth of the saturated water bearing material. With the large number of holes put down on this area the average depth of saturated water-bearing material was determined, and was approximately 20 ft.

The velocity of flow is governed in a large measure by the size of the sand and gravel particles, the coarse material permitting the water to flow much more freely. As stated above, the material ranged in size from fine sand to particles of gravel 1-in. in size, the samples taken from the different holes giving positive information on this point.

The available ground storage in this case was determined by learning the length, width, and depth of the saturated water-bearing material, computing the storage in gallons on the basis of one-third the volume of sand being void space, and also on the basis that one-third the average annual rainfall, or 12 ins., was the available underground run-off. "Water Works Management and

Buried Treasure



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Maintenance" by Hubbard and Kiersted, gives additional information on this point.

It is thus seen that the elements of uncertainty as to the well supply have disappeared, that we have definitely determined the water shed area, the capacity of the underground storage basin, the size and quality of sand or gravel bearing deposit and the rate at which it may be expected that water will flow through the deposit to the wells.

It is interesting to note here that engineers too frequently fail to cite their authority for engineering practice which they propose. The average water works official is very slow to dispute an engineering principle laid down by an authority on the subject, just as he is slow to argue when his attorney cites some legal principle and presents his Supreme Court decisions or his other proper authorities.

Testing Supply

A most important feature in the development of a well supply of water, as considered by some authorities, is a long continued pumping test, covering a period of several weeks or several months. While a sparkling stream delivered from a well for several weeks will look quite convincing to many officials, and in fact may prove of some value in a study of the supply, it is probably more often misleading than valuable. As an illustration, assume we desire to test a well by pumping at a rate of 1,000,000 gals. per day for 30 days, also that the deposit from which the supply is furnished has a storage capacity of 60,000,000 gals., with a somewhat limited water shed area. It is readily seen that the well might be pumped the full 30 days and appear to be strong at the end of this period, when as a matter of fact an additional 30 days' pumping would exhaust the supply. It is readily apparent, therefore, that a pumping test alone cannot be conclusive.

The pumping tests at Witt were carried on over a period of about two weeks. However, it was frankly stated to the officials at the time that a pumping test over any considerable number of days was not necessary in view of the previous knowledge of the fundamental elements which controlled the supply. During the time tests were being made, Mr. Habermeyer, Acting Chief Engineer of the State Water Survey, was present and the following extract from his report of Aug. 6, 1918, to the officials of Witt is here given.

"The test of the well indicated a large quantity of water available. A yield of 70 gals. a minute was secured when lowering the water level in the well about 8 ft. to a depth of about 14 ft below the ground surface. (The well was 6 ins. in diameter, and equipped with a No. 20 Cook screen, 6 ft. long.) With the greater area of openings in screen or greater lowering of water level a greater yield would be secured. The ground water level was lowered but a little at a distance of 20 ft. from the well."

Special Features of Witt System

The final plan at Witt was to construct a circular concrete pump house, 22 ft. in diameter, built over two 10-in. wells spaced 18 ft. center to center, the pump house being set 10 ft. in the ground in order to reduce the lift of the centrifugal pumps. There will really be only about 6 ft. of lift for the pumps under present conditions, due to the level of the water in the ground.

Another feature of interest is the reinforced concrete water tank, built on the highest point in the city, the tank being 20 ft. in diameter and 100 ft. in height, the upper 30 ft. having 70,000 gals. storage capacity.

Two pumping units have been installed, being electric motors, either of which has sufficient capacity to take care of normal requirements.

The writer believes it would have been a better plan to have installed possibly one electric motor and one automobile-type gasoline engine, as auxiliary source, each connected to a separate centrifugal pump.

The total cost of the supply system, including wells, pumping station complete with equipment, 8-in. cast iron pipe line to city limits, a distance of 3,000 ft. and the 70,000 gal. reinforced concrete water tank was less than $25,000 or about one-fifth the estimated cost of an impounded supply.

The distribution system was let as a separate contract in 1919, and cost approximately $10,000 per mile, including valves and hydrants, the total cost of the distribution system being about $70,000 for the seven miles. It is thus seen that the entire cost of both the supply and distribution systems was only about 75 percent of the estimated cost of an impounded supply alone.

Value of Rational Method

Careful examination of the location of known shallow-ground wells with reference to area of water shed, will demonstrate the proposition stated by Hubbard and Kiersted that "The yield of the ground water is dependent upon the character and extent of the catchment area and depth of the saturated water-bearing material."

A most interesting illustration of this is found at Bloomington, Ill., where the supply is secured from shallow-ground wells. Here the water shed area is only a few square miles at most, while the depth and area of the saturated water-bearing material is necessarily somewhat limited. Year after year desperate efforts have been made there to secure more water from this saturated water-bearing material, and yet the proposition that "no more water can be continuously taken out of the ground than goes into it" has never been fully recognized in the study of the situation, unless possibly within the last months.

We refer again to Hubbard and Kiersted: "Shallow-ground water supplies are usually developed from sand and gravel deposits in the valleys of creeks and rivers." In this connection, what are the limits of the deposit at Bloomington? Does it continue down the valley to a point where the catchment area and the depth of deposit are sufficient to supply a future city of 100,000 people? What is the character of the gravel further down the valley? These are important factors, and could be definitely determined at very small expense.

Recently there was witnessed an effort by a city of 5,000 population to secure a shallow ground water supply from wells located on a catchment area of only about one square mile. Twelve or fifteen wells were put down on one 40-acre tract, and pumping of water in one well lowered water in all the others. Was this a Ra-

tional Method of Water Supply Development? We hardly think so.

In another city a test was made on a shallow well, driven into about 11 ft. of coarse gravel and the supply was pronounced a failure, when as a matter of fact there was a continuous deposit of sand up and down the valley, and available records of the State Geological Survey showed that there was a deposit of 90 ft. of gravel within a quarter of mile of the well tested, with about 50 square miles of catchment area above it.

These are only a few cases which point to the necessity of careful study and intelligent application of the fundamental propositions which govern the development of shallow-ground water supplies.

Goodell, in his book, "Water Works for Small Cities and Towns," has also given us valuable information on this Rational Method in the following language: "The amount of water that may be obtained from deep and shallow wells is so often over-estimated that it is necessary to call attention to the fact that the quantity available depends on the *same* conditions as the amount of surface water, that is, the extent of the catchment area, the rainfall, the proportion of the rainfall entering the ground and the capacity of the basin to hold ground water."

It will, of course, be borne in mind that where a deep or artesian well is to be developed, a careful geological examination will be necessary.

Turneaure & Russel in "Public Water Supplies" refer to collecting areas for ground-water as follows:

"Deposits of porous material in old lake and river beds often furnish very good collecting areas for ground-water, and many of the shallower ground-water supplies are from such sources. These deposits are usually covered by other and less pervious strata, and indeed often consist of a series of strata alternately of a pervious and non-pervious nature. This is particularly true of the lacustrine deposits in the basins of the Western mountain region. Old river channels filled with debris of a porous character give rise to veritable ground-water streams. These may be located some distance from the modern streams, or may at places coincide with or underlie them, forming porous, gravelly beds.

"Examples of such ground-water streams are very numerous. Leipsic, Germany, is supplied from such a stream about 2 miles in width, 40 ft. thick, and having a fall of about 6 ft. per mile. The covering stratum is 6 ft. thick, and the velocity of flow is estimated at about 8 ft. per day. Pueblo, Colorado, is supplied with water from a gravel bed 66,000 sq. ft. in cross-section with an average depth of 14 ft. and a length of 25 miles. Deposits of sand and gravel in the drift are often of considerable extent, and furnish many ground-water supplies, but such deposits are apt to be very irregular in character and uncertain in extent. They occur as accumulations in former stream-beds and also in the form of thin, irregular strata, sometimes of considerable extent, lying for the most part in valleys and covered with more or less clay."

It occurs to the writer that we too often fail to make our examination sufficiently broad to learn the true location and character of the collecting area, from which we might secure well supplies.

It is a matter of record in this state, as it is also in many others, that we have sand and gravel deposits scattered over a greater portion of the area, that they follow in a general way the old original valleys, sometimes conforming to the outlines of the present valleys; and it is the belief of the writer that a careful application of the principles above outlined will enable a great majority of our cities and towns to develop water supplies from such gravel deposits in an economical manner.

Conclusions

In conclusion it is desired to direct attention to the following propositions.

1. With a saturated water-bearing material located on a catchment area of proper extent a shallow-ground water supply will ordinarily be developed at far less expense than an impounded supply.

2. The radius of investigation for shallow-ground water supplies should be increased so that it shall include not only the city limits but extend for a distance of 5 or possibly even 10 miles beyond the city limits, depending on local conditions, and the availability of an impounded supply.

3. The quality of water secured from one test well in a valley may be entirely different from that in another well in the same general region, due to deposits in the original valley produced by the action of currents. Intersecting creeks and branches will very often show a marked influence on the character and quality of the saturated water-bearing material, and the water contained therein.

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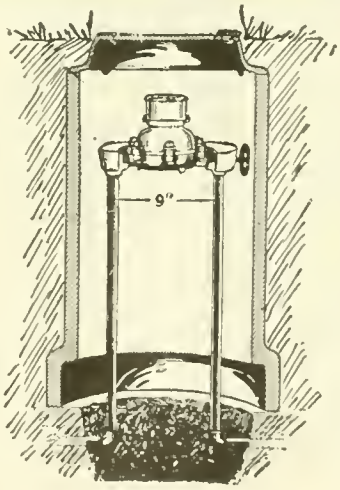

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4. The quantity of water available from a saturated water-bearing material should be determined for various cities as fully as has been done in the case of Pueblo, Colorado, and comprehensive studies of this character should be made a matter of public record in order that the fullest use may be made of them by other towns and cities.

The Rational Method of Water Supply Development herein discussed does not present any new theories, but does contemplate the application of known engineering principles along such broad, comprehensive lines, as judgment and experience may dictate.

Acknowledgment

This paper by Mr. Warren was presented at the 1920 annual convention of the Illinois Section of the American Water Works Association.

WATER WORKS REQUIREMENTS FOR SMALL AGRICULTURAL VILLAGES

By Edgar A. Rossiter, Consulting Civil Engineer, 127 N. Dearborn Street, Chicago, Ill.

One of the first ear-marks of progress in the small community is the installation of modern water works. It is the forerunner of home conveniences that tend to hold the boys and girls in our rural districts. The lack of modern conveniences has depopulated many a farm and village in favor of the larger cities.

One of the greatest educators along these lines has been the mail order catalogue. Its highly illustrated bathroom scenes, showing snowy white fixtures, have created a desire for something better than the rural districts afforded.

The individual air pressure system, with its freely flowing water, has silently been another factor in awakening the village to the necessity of a public water supply. There are still some villages in our central states of a population of over one thousand inhabitants that have no public supply system. There are many hundreds of prosperous villages of over 500 population that are without a public water supply for fire protection and domestic uses.

In Illinois, the laws are extremely favorable to the installation of a municipal water system, and to one who knows the ropes the plan is simple.

Sources of Supply in Illinois

The first consideration is the source of supply, which varies with the geological formation. Where the glacial drift has deposited large beds of sand and gravel the shallow well, ranging in depth from 100 to 200 ft., has give a sufficient supply which is practically bacteriologically and chemically pure and is reasonably soft.

A fault in the limestone formation at a depth of 200 to 400 ft. has sometimes given a fairly satisfactory flow. In some localities the mineral content is such that the use of the water is prohibitive. The peculiarity of the supply is such that at first there is but a faint taste of sulphur, but as the years go by and the pumping continues, the iron pyrities, sulphur and oxygen create a mixture that is not drinkable. The water is also hard and cannot be used in boilers or in the laundry.

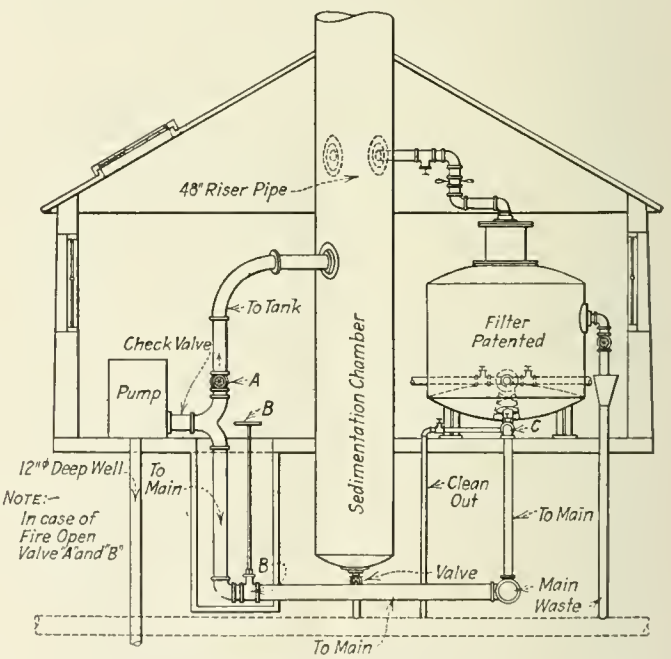
The deep wells range in depth from 1,100 to 1,800 ft. where a water of varied degree of hardness is obtained, and the mineral content is such that frequently it is useless for boilers or laundry. The supply coming from the St. Peter and Potsdam sandstones are good drinking waters, though hard. Below the Postdam a salt is often found which if drilled into will convince the owner that a consulting engineer would have been a saving proposition, as an expert would have prevented such a catastrophe or would have been able to plug the hole at the proper place to eliminate the salt.

The surface water from creeks, rivers and lakes gives a supply subject to more or less contamination, often requiring sterilization, coagulation or filtration.

The Financial Question

Concurrent with the source of supply the financial question is of vital importance. Proper rates must be charged to place the plant on a paying basis so as to retire the water certificates when due. In designing a small water works plant the element of economy is more vital than in larger installations, in order that financial failure be prevented.

Fire protection and an inherent demand, or hope, for a reduction of insurance rates, go hand in hand with the



COMPACT WATER SOFTENING AND FILTRATION PLANT FOR AN ILLINOIS VILLAGE.

economy of design, and the proper fire protection should be the governing factor in the distribution system, the spacing of valves and hydrants, together with the proper equipment for the power station.

Power station and equipment depend on many phases of the construction. First, the designer must have in mind that a reduction of fire insurance rates means in fifteen years a saving of the cost of the plant, and that in order to obtain such reduction the Board of Fire Underwriters must approve of the design of the plant. Second, one must consider maintenance cost or yearly upkeep. Third, uniformity of power supply and the dependability

on its operation when needed. Fourth, the installation should be as free of complicated equipment as possible.

Where the village covers a very closely settled tract, not spread out over a large territory, the air pressure system has given satisfaction, provided the tanks are large enough and the power so arranged that oil engines and electric motors can be used in case one or the other breaks down.

The most efficient and economical installation, however, for a village is the tower and tank, ranging in capacity from 40,000 to 100,000 gals., elevated from 100 to 120 ft. Pumps operated by oil engines, with an electric motor as auxiliary power, the pump working directly into the tank and by-passed into the main for fire use. The tower and tank system having a pressure of 50 lbs. and a capacity of 40,000 to 100,000 gallons, is always ready in case of fire. Even if the current is shut off the operator still has the tank full to work on.

I have often wondered what some air pressure systems, electrically operated, having small tanks, would do if lightning struck the town starting a big fire and the Public Service Company cut off the current, as is frequently done.

Pumps, either deep well or surface, should be of the highest mechanical efficiency obtainable, using if possible oil and electric motor for power and should have automatic control.

In a plant recently designed where a hard water, having certain mineral content, including iron, is obtained, the water is aerated during pumping, a softener injected, the precipitates falling to the bottom of the standpipe as a settling basin where a blow-off valve is placed. The supply is taken out of the standpipe 10 ft. above the bottom, passing through a filter (except in case of fire), the entire treatment cost adding but a small amount to the investment.

The distribution system depends upon the make-up of the town, location of schools, churches and buildings and the probable increase in size of the town. The actual consumption of water for domestic purposes could possibly be supplied through a 4-in. pipe, but for fire protection the size of mains will depend upon the number of streams estimated to be necessary, the distance from the plant and friction losses, and the sizes put in will run from 8 to 12 ins. in diameter with 6-in. laterals.

Valves should be placed so that certain portions of the mains can be cut off for repairs without closing off the entire system. Hydrants should be spaced not farther than 330 ft. apart for good fire protection. Mains, valves, hydrants and all other equipment should be of standard make and of the very best of its kind or the repair bills will prevent the payment of the original installation.

In the small town water works plant, electric and oil engine power should be used, as this will reduce the operating expense to a minimum, for in many towns the marshal attends to the station, reads the meters and makes out and collects the water bills.

STEAM POWER PLANTS FOR PUMPING STATIONS

By P. J. Kiefer, Asst. Professor, Steam Engineering Department, University of Illinois, Urbana, Ill.

In 1900 the Allis engines at Chestnut Hill Pumping Station, Boston, gave a duty of 157 for the engine only, the then lowest coal consumption of 1.06 lb. per indicated horse-power hour and an (estimated) overall plant duty of about 125. Since this date my impression is that there has not been any considerable gain in reciprocating plant efficiency except in cases of the use of the Uniflow type of engine. Lacking quickly accessible actual test data I have estimated that, using the highest type of Uniflow engine with high pressure and superheat and with a high grade of boiler installation and operation, the over-all duty figure might perhaps be brought to 135 or 140. It does not seem probable that any considerable gain over this may be expected with the reciprocating unit.

The Steam Turbine

The steam turbine has, of course, made a very spectacular advance in the electric power generation field during the last several decades. By the use of higher pressure, temperature and vacuum it has in the larger sizes obtained somewhat higher heat efficiency than that afforded by even the better class of reciprocating engine, although little, if any, better than that available with the Uniflow engine. The extremely rapid and complete displacement of the reciprocating engine by the turbine in this field has been due, however, not so much to any great gain in heat efficiency as is popularly supposed, as to its great economic advantages, such as the possibility of enormous concentration of power capacity into simple machines occupying small space, costing less initially and less for operating labor, all highly important factors in a plant operating with the relatively low load factor of the usual electric station. Its introduction in this field has again been co-ordinate with the development of the high speed electric generator.

Its advance in the pumping station has been much less rapid due to two or three basic and, to my mind, quite legitimate reasons. First of these has been perhaps the much less rapid expansion of pumping station loads, without the necessity for hasty and extensive increase of plant capacity such as been experienced in electric power generation. This condition would tend to support any inertia which might reasonably be anticipated in so old and well established an industry. Another reason has been that the efficiency of the centrifugal pump has failed to measure up to that of the high grade reciprocating pump, thus counterbalancing any gain that might be made otherwise by the use of the turbine. Again, first cost and the resultant fixed charges have not been such important elements on account of the very high load factor available in the majority of pumping plants. This has further made it possible to obtain the best of efficiencies with the standard apparatus and let it be said to the everlasting credit of the pumping station designer and operator that they have taken excellent advantage of their opportunities and it has usually been they who have set up the record toward which other engineers might strive.

Turbine and Centrifugal Pump

However, returning to the question of the use of the turbine and centrifugal pump and attempting to look into the future, it does seem probable that their introduction in the pumping station field will be continually more rapid. Reliable authorities predict the early commercial development and use of the 500-lb. boiler with 250 or more degrees of superheat. Turbine builders claim that under these conditions a turbine efficiency as high as 85 per cent. of the theoretically ideal efficiency may be obtained. Making high but not unreasonable estimates it appears that with such apparatus a plant duty of 150 might be obtained. It does not seem likely that the pumping station engineer will sidestep this opportunity, especially in the face of the rising cost of fuel. However, even before such time he may already have accepted the centrifugal pump, either turbine or motor driven, for other quite positive reasons, or again he may have taken the advantage of the higher efficiencies of the internal combustion engine.

Fuel Conservation

In all of this we have been looking at the basic fuel conservation problem from a rather narrow viewpoint. We have been reading and hearing so continuously of the necessity for fuel conservation that some with efficient plants may have become tired of it. I do not wish to be pessimistic in this connection, but it nevertheless seems true that should we in the future maintain the same annual rate of acceleration in our consumption of solid fuels as we have in the past century our higher grade fuel coal, will be exhausted in a very few years and all of our solid fuels, including the lignite and peats, would be used up in another century or two. Our crude oil supply is estimated to be about 50 per cent. exhausted already after only a few years' use and with rapidly increasing production at present. I anticipate that necessity and ingenuity will combine to decrease this rate of acceleration in fuel consumption and the above figures are extreme, but at the least the soaring coal and oil prices can hardly fail to drive home the idea that some sort of changes are approaching.

Some may have read in the recent technical press of the "super" power generation project seriously proposed for the Atlantic coast industrial zone, involving the elimination of all the less efficient small plants and plants without heating load with the concentration of electric power generation into enormous plants in the mine regions and at strategically placed water front locations, all coal to be given perhaps a preliminary by-product treatment and all available hydraulic power sites to be developed. An annual saving of $300,000,000 is estimated (Breckenridge). Such a scheme is not at all visionary and if developed might clearly be expected to affect vitally the policies and procedure of even the efficiently operated pumping plant which is located at some distance from the mines. I believe all of us realize the quite sizable loss of ultimate thermal efficiency and great loss of economic efficiency in having some 28 per cent. of our railway transportation engaged in hauling coal here and there about the country for us to waste far too often in a shamefully inefficient plant.

We have been speaking of high efficiency plants and of hypothetical plants giving a duty of 150. We take pride in our prime movers which transform into work 75 per cent. or more of that portion of the energy in the steam or gas which is theoretically available for such transformation. Likewise we are proud of the boiler with 75 per cent. efficiency. Let us not forget that in the very process of combustion at high temperature and subsequent partial absorption of the heat into much lower temperature steam we make absolutely unavailable for power generation purposes about 75 per cent. of the original energy in the fuel. The internal combustion engine is some better but not a whole lot. Unfortunately any of our present devices for power production from the energy of fuel basically are distressingly inefficient, but they are all we have and we must make the best of them. Would it have been any more visionary several centuries ago to have predicted the modern locomotive, turbine, aeroplane, wireless and innumerable other miracles, than it would be now to predict the discovery in no great number of years of some simple scheme for transforming the chemical energy of fuels directly to electrical energy without the wasteful intermediary combustion and engine, with perhaps 90 per cent. instead of 25 per cent. efficiency?

The foregoing is the major portion of the address delivered by Prof. Kiefer at the recent annual convention of the Illinois Section of the American Water Works Association.

CONSIDERATIONS AFFECTING THE DESIGN OF SMALL WATER WORKS

By J. Q. Wickham, Consulting Engineer, 300½ Main St., Ames, Ia.

To the average engineer and city official the designing and planning of public water supply works for the small cities and towns is of prime importance, and the present article discusses the major considerations affecting the design of such works.

First, Locate the Water

The first and most important matter of course is the choice of supply, without which any plant or system is a failure, and in the estimation of the writer, this is the most important step to be taken. There seems to be something wrong about the idea of procedure in this matter, owing it may be to too much promotion upon the part of some supply man, engineer, or some other interested agent, which should not be so. One of the biggest excuses most parties have for getting at the work in a wrong way is that in most cases a bond issue must be put through and a general plan and estimate must be given to show the voter why he should vote for a water supply system. This may be all well and good, but even though a bond issue has passed it would appear that before any final plans are drawn the matter of the water supply should be ascertained. The writer has in mind at the present moment a town that has a new complete wa-

ter system, tower and tank, pumps, motors, etc. all installed and not a supply in sight. Had the town made sure of water before expending money for the elaborate system that now in any event must be altered to meet the change in location of the supply, much time and trouble might have been saved. Today, they are putting down a well some two miles from town, and if the water supply proves adequate the system as installed is exactly opposite to what it should be. If this was the only case where the matter of the supply had been overlooked it might not be so serious, but there are many other examples of the same kind. It would appear therefore that the first and most important matter should be the obtaining of a good and adequate water supply, making thorough tests and investigations in advance of expending money for any expensive pumping and distributing system.

What Constitutes an Adequate Supply?

To some of us the matter of what might constitute an adequate supply would appear easy, while to others it might seem vague. On account of this it may be necessary to draw a few examples of what constitutes an adequate supply. For instance, a small town has in one section an excellent quality of water for small drilled wells delivering a maximum of 30 gals. per minute, while in another portion of the town a lower quality of water from a gravel bearing strata, supplying a maximum of 50 gals. per minute. What would be an adequate supply if the town required 30,000 gals. per day for domestic use, and a public utility plant in the way of a canning factory requiring 110,000 gals. per day?

It can readily be seen that one small well delivering 30 gals. per minute would not supply a maximum of 140,000 gals. per day. Many of the citizens in that section of the town, with the good quality of water, having no conception of the amount of water required, declared that their wells could not be pumped down (having used them only for house purposes) but upon test these wells were found to supply only the 30 gals. per min. as before stated. From the tests it was found that certain wells could be pumped without affecting others nearby. Furthermore, while the supply from individual wells was limited, they stood up well under the test, and as the water came from rock formation, only a little more than 100 ft. from the surface, and stood at a level of 15 ft. from the top, it was recommended that seven 6-in. wells be driven cross-wise of the vein, 25 ft. apart connected together at the 15-ft. level into one central pump-pit 15 ft. deep, and there attached to a 100 gal. deep well type of triplex pump. It may be somewhat out of the way to go into specific detail in this one instance but the object is to show that the matter of the supply should be carefully thought out in case there is any doubt as to quantity or quality. In some towns it is impossible to get the required supply without going to a great depth and even then it is of poor quality. Other towns are required to go several miles distant for a supply, to natural springs, water bearing gravel, or streams. It must be borne in mind, therefore, that even though the population is clamoring for action, the engineer and council should make sure of their supply before final plans are to be made.

The Amount of Territory to Be Served

The details of the final design are, of course, of considerable moment and some of the more important details will here be given. One of the first things in the matter of the design, after the source of the supply has been settled upon, is the ultimate amount of territory to be served. This is of vital importance for the reason that even though only a portion of the system be put in at the beginning a comprehensive design is necessary to provide for future adequate and proper extensions. As an example of lack of a good general design and plan it is only necessary to go into almost any small town or city and note where extensions have been made from the nearest point, going in one direction, for a block or two, then in another, making a zigzag line often running by property that will never need any service. A comprehensive plan, therefore, should be settled upon and carefully adhered to regardless of the desires and whims of some interested property holder.

The manner of laying out the mains often gets but little attention and this should be impressed more fully on the mind of the party making the plans. Not that the parties interested have not felt that they were doing the very best by the city or town they represent, but because the ultimate result of their work was not clear to them. For instance, there have been many systems of piping laid out with the idea of fire protection as the real object, and the matter of service to the individual property holder not once considered. As an example of this the attention of the reader is called to a town which had a complete water works system and an exceptionally good fire protection, but it was so arranged that not more than twenty families could get water service in their homes without going considerable distance for it. The reason for this was that the mains instead of passing along the streets upon which the lots abutted, were upon the cross streets, making it necessary for all parties in the middle of the block to run a service at least ½ and sometimes 1½ blocks to get water into their residences. This could just as well have been avoided by running the lines in the system in the other direction, serving the same fire district as well as taking care of the individual property holders. The designer should therefore bear in mind that ultimately the property holder will use city water in their properties and should only be required to go to the abutting street to attach his service to the main. In other words the main should pass along the streets which have the most abutting lots.

Special Castings

While we are on the matter of the general layout of the mains it might be well to mention another matter of more than passing note, which is the lack of specials, such as tees, valves, etc. that are installed in most mains. Of course as far as valves are concerned the use of a tapping machine is supposed practically to eliminate the necessity of cutting off the water, but from past experiences of most superintendents and public officials it would appear that one should be put in every block. This might verge upon extravagance, but in any event any line that has a posibility of extension should have a valve placed at the end where work has stopped so that upon con-

(Continued on page 231)

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(Continued from page 229)

tinuation the water in the existing main will not have to be cut off. The matter of the specials is of equal importance with the valves and they should be set in at every intersection regardless of whether there is an apparent need for them at the time or not. This should include tees for hydrants as well as crosses for all cross streets. While on the matter of specials, it might be well to call the attention of all superintendents and other officials to the fact that it is poor policy to set hydrants without a valve in front of them, as they are sure to get out of repair, and if no valve is placed some difficulty will be experienced in fixing them.

Pipe Sizes

The location of the well will determine largely the size and location of the mains on some of the streets, perhaps, but as a rule not less than an 8 in. should be laid from the pump to the elevated tank, if one is required, and not less than a 6 in. within the business district; while in the residence district not less than a 4 in. main should be used. It is true that a number of cities and towns have installed as low as 1¼ in. mains, but at best they are only temporary and in the long run must be removed and replaced by larger pipe, making the final expenditure sometimes as great as would have been necessary to have put in an 8 in. main in the first place. It is therefore advisable under most conditions to have no mains smaller than 4 in. and as much larger as the conditions demand. It is quite customary, and is getting to be general practice, to place the mains not on the centerline of any street but to one side. The side selected depends on conditions, but usually mains are laid on the north side of east and west streets and the west side of north and south streets, at a distance of 23 ft. from the north and west sides of the corresponding streets. Also for the convenience of the firemen as well as affording some better protection from freezing, the northwest corner of the intersection, is selected for the location of all hydrants. The object of keeping on the 23-ft. line is to leave the center of the street for sanitary sewers as well as making a convenient setting for the hydrant.

Pumping Equipment

As to pumping equipment, it would be impossible to make a hard and fast rule as to what is best to use, owing to the wide variation in the demands, but for the average small town, where wells are used, some form of the deep well type of pump meets most often the requirements. However, a study of the exact situation may demand a certain type of pump in one town and a different one in another. It might be well to state at this point that pumps are not always sold on their adaptability for a certain condition in the town.

The pressure for ordinary house use it usually about 40 lbs. in most cases and is supplied by an overhead tank on a tower or stand pipe or by pressure system. The pressure system, in cases of very small towns (of say 300 to 500 people) makes a system that is usable, but is not very dependable in case of large unexpected fires, and in many cases as soon as the town can stand the expense an elevated tank on a tower is put in its stead. The direct pressure system is but seldom used in the smaller cities and towns, the reason for which cannot be discussed in this short article.

Suggestions on Design

The following suggestions are given as a guide to the planning and designing of water works systems for small cities and towns:

1. Make sure of a pure and adequate supply.

2. Make plans to cover all future needs as far as possible. In other words, so lay out the system that it can be extended in any possible direction.

3. Lay out mains in such a way as to serve the greatest amount of property holders, without their having to go farther than the abutting street.

4. Make extensions in conformity with the original plans, as far as practicable, bearing in mind that all cities and towns have a tendency to increase in size.

5. Be sure to insert sufficient tee's, crosses and other specials, at each and every intersection.

6. Make a practice of laying the main on a certain side of all streets preferably 23 ft. south of the north line of all east and west streets, and 23 ft. east of the west line of all north and south streets.

7. Select a certain corner of all intersections for the location of the hydrants, as far as possible, preferably the northwest corner.

8. Make a practice of putting in a gate valve in front of all the hydrants.

9. Choose a pump that is adapted to your needs.

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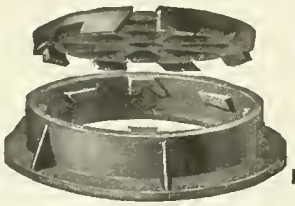

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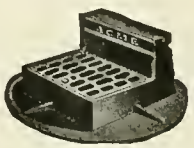

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CONSTRUCTION NEWS AND EQUIPMENT

IN OPENING UP GRAVEL PITS CITIES AND COUNTIES SHOULD ADOPT METHODS SUCCESSFULLY EMPLOYED BY COMMERCIAL PRODUCERS

From now on the limiting factor in many highway construction and street paving operations will be the supply of materials. Several factors influence the material supply, including car supply, labor and the number of sources supplying the raw, road-making materials.

Some states that now have large road-building programs had scarcely constructed a modern highway until a year or so ago and consequently there has been no inducement for anybody to enter the business of producing road making aggregate in those states. In other states the existing commercial sand and gravel plants are generaly adequate for the territory they serve, but they are

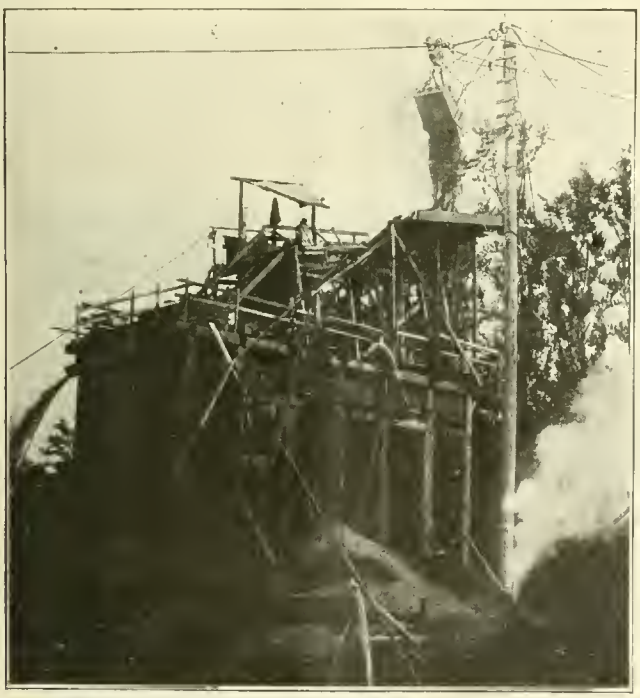

FIG. 1—DRAGLINE CABLEWAY BUCKET DUMPING MATERIAL INTO HOPPER OF CONTRACTOR'S SCREENING AND WASHING PLANT.

handicapped by lack of sufficient open top cars to ship all the materials they can produce, and, furthermore, the demand from the road builders comes all in the space of a few months instead of being spread over a period from March to November as it should be.

It follows that local sources of road-making aggregate will be investigated more and more by contractors and road officials, and many deposits of usable materials, now idle or inadequately worked, will be properly developed.

Do Not Adopt Makeshift Methods.

Of course there will be many ventures by men lacking experience in this field that will come to grief. Opening up a gravel pit and properly equipping and operating it are not simple matters, but contractors, municipalities and counties have made a success of it when they have patterned after the commercial producers instead of adopting makeshift methods.

It is generally recognized in the sand and gravel field

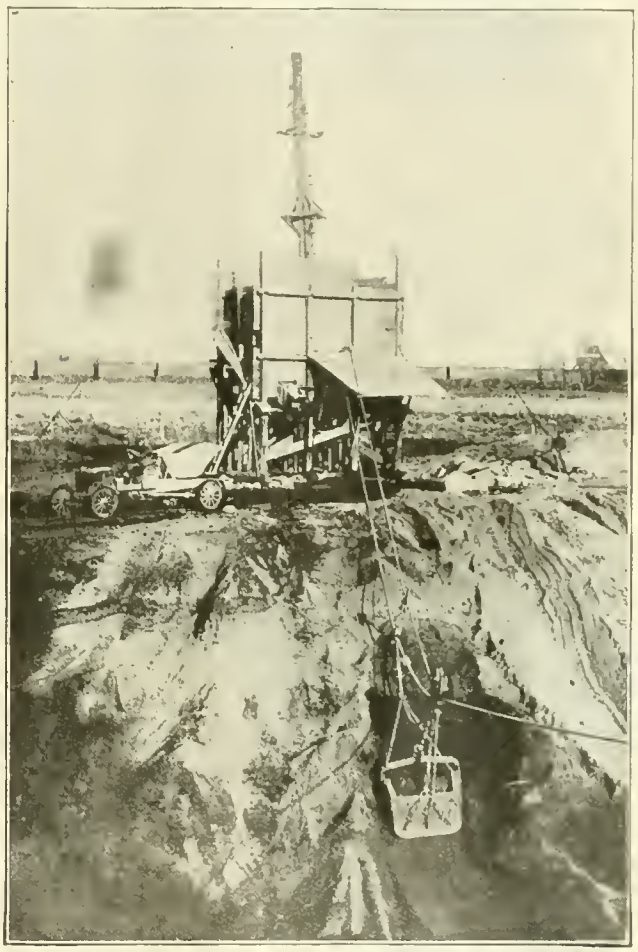

FIG. 2—WORKING A LOCAL PIT WITH SAUERMAN DRAGLINE CABLEWAY IA CONNECTION WITH PAVING JOB.

that for small and medium-sized plants, that is, plants producing from 100 to 1,000 tons per day, the dragline cableway excavator offers the best method of excavating and handling the materials. This type of equipment, operated by one man, will dig and carry materials over a long span in one movement without the help of auxiliary conveying equipment and will work under water as efficiently as in the dry pit.

It is apparent that the operation and upkeep of equipment of this type is not expensive, and this low overhead cost particularly recommends it to highway boards and contractors when they are compelled, through lack of a nearby commercial gravel producer, to develop their own

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source of supply. In the state of Washington, for example, where commercial gravel plants are few and far apart, at least a dozen dragline cableway excavators have already been installed this season by contractors who are producing their own materials for road jobs of from 4 to 15 miles long, and one Washington county is operating four of these outfits to supply aggregate for the county highway and bridge work.

County Plants in State of Washington.

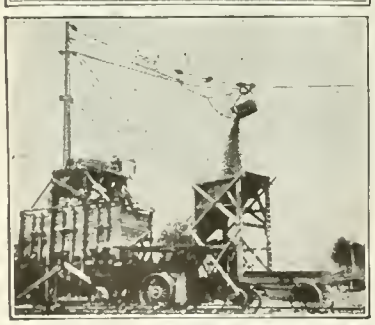
These Washington plants vary in size according to the requirements of the individual contractor, the smallest installation being one for excavating 80 cu. yds. of river gravel per day for re-graveling a county road. A very efficient plant is being operated by Ledingham & Cooper of Bellingham, Wash., to furnish aggregate for their concrete road job near Acme, Wash. They located a fine deposit of gravel in the bed of a river close to the road and about midway along the job. Here they installed the complete screening and washing plant with a 500-ft. span, ¾ cu. yd. Sauerman Dragline Cableway Excavator illustrated in Fig. 1. This size of dragline cableway excavator is capable of excavating and delivering to the screens about 250 cu. yds. in 8 hours, but by working two shifts, the Ledingham & Cooper plant has turned out 500 cu. yds. of washed and screened material per day when it became desirable to push the concreting on a faster schedule than was originally planned. Seven 4-ton motor trucks, also operated in two shifts from 7 a. m. until midnight, haul the sand and gravel from the plant to the mixers.

Contractor's Installation at Estherville, Ia.

A type of dragline cableway gravel outfit adapted to temporary use is that installed at Estherville, Ia., by the Des Moines Asphalt Paving Co., shown in Fig. 2. In making their advance plans for maintaining a fast schedule on a large paving job at Estherville, this contracting firm found that difficulties in getting gravel shipped into the town might interfere at any time with the progress of laying the concrete paving base. Accordingly they took over a partly worked municipal pit and put in a 300-ft. span, ½ cu. yd. dragline cableway excavator with small bin for loading motor trucks, which gives them a dependable supply of 200 cu. yds. of aggregate per day at a low cost per yard. The dragline cableway excavates, conveys and dumps the material onto a grizzly bar on top of the bin structure. Screening is unnecessary, as the material, except for a few boulders which the grizzly rejects, is uniform in composition and suitable in its neutral state for concrete base. The aggregate is handled from the bin direct to the charging skip of the mixer several miles away by using light trucks equipped with Lee end dump bodies. Each truck carries 1 cu. yd. of sand and gravel and three bags of cement per trip. With the haul averaging about 6 miles round trip, seven of these light trucks keep the mixer constantly supplied with materials.

A Michigan Township Installation.

Township and county road commissions sometimes face a situation much similar to that which confronted the Des Moines Asphalt Paving Co. at Estherville, and



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Solving Your Gravel-Handling Problem
It is not so difficult to decide what type of equipment is best adapted to your particular sand and gravel proposition if you will bear a few points in mind.
Just remember that a Sauerman Dragline Cableway Excavator will dig over long spans and to any depth, enabling it in most cases to handle the gravel from pit to plant direct without the help of auxiliary conveying equipment.
Remember also that a Sauerman Dragline Cableway Excavator is especially economical and efficient for digging sand and gravel from under water, as witness its frequent use instead of a pump or dredge.
For a specific recommendation on equipment suitable for your operations, write us in detail about your ground conditions, daily output wanted and other requirements of your proposition and we will give you our frank advice.
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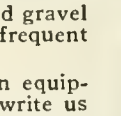
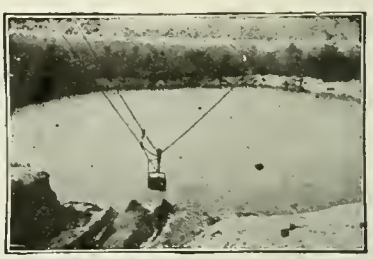

P & H Excavator-Crane Excavating a Ditch and Grading a Road.

Road Builders' Combination Machine for Excavating, Grading, Backfilling and Material Handling

The P & H Excavator-Crane is a successful answer to the problem long recognized by contractors and manufacturers of producing one piece of equipment capable of performing the four general functions of Excavating, Grading, Backfilling and Material Handling. The four major uses of this equipment by road builders are as follows:

Grading Roads. Where road beds are low and need "shouldering up," or where fill must be made through water-logged and swampy land, the P & H Excavator-Crane will pull in and heap up the ground much faster and cheaper than will teams and graders.

Making Cuts. The P & H will make cuts in roads at the rate of 300 to 500 yards per day. The average cost seldom exceeds $20.00 for a day's operation. When the excavated material is loaded in wagons, the capacity is reduced only about 10 per cent. For constructing drainage ditches, the P & H is run alongside or center of the completed road, excavating the ditches to the required depth and wasting the dirt on the slope of the road bed or beyond the ditch. On this operation the machine cost is rarely over 8 cents per yard, even when handling wet earth where it is often impossible to work teams.

Excavating Gravel. Capacity (approximate) 300 to 500 yards per day of gravel from the bank into trucks and wagons. The hauling equipment, working with a P & H, is never in the excavated hole as it is with steam shovel or trap loading. The P & H Excavator-Crane has a full circle, non-obstructed swing with an operating radius of 30 feet.

A Complete Portable Locomotive Crane. Equipped with a hook, magnet or other grappling device, the P & H is a complete portable locomotive crane with a lifting capacity of 3,500 pounds at 30-foot radius. Great for cleaning up a yard, placing pipe in trenches, pulling piles, moving the bulky stuff, loading and unloading cars. Remember the P & H has a full circle swing and is entirely self-contained, ready to operate on any spot without propping or stabilizing of any kind; worth its cost for this ability alone.

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P&H — excavators — back-fillers - tampers

FIG. 3—VIEWS OF SMALL SIZE EQUIPMENT INSTALLED BY ROAD COMMISSIONERS OF A MICHIGAN TOWNSHIP. THIS PLANT PRODUCES SAND AND GRAVEL SUFFICIENT FOR ALL THE TOWNSHIP ROAD WORK.

are able to make profitable use of the smaller dragline cableway excavator outfits. In Fig. 3 is shown the plant which last season produced all the gravel for building and maintaining roads in a certain Michigan township. The township commissioners installed this plant when they found that they were outside the economical shipping radius of the nearest commercial producers. They leased a tract of several acres of gravel and put in a 300-ft. span, 1-3 cu. yd. dragline cableway excavator in connection with which they used a portable bin and screen taken out of an old wagon pit. The bucket delivers the gravel to a hopper, where the over-size material is separated and dropped down to a crusher, to be crushed and re-elevated, while the finer material is chuted direct to the screen over the loading bins. This size of outfit is satisfactory where the amount of material required per day does not exceed 125 cu. yds.

Deposits of gravel are among our most important natural resources and the proper opening up and operation of gravel pits is a study worthy of the attention of all city and county engineers and contractors. However highly developed the art of hard surfaced road construction may become, gravel will always be used, not only as coarse aggregate in concrete, but for the construction of gravel roads.

USING THE STEAM SHOVEL IN ROAD AND STREET WORK

It is a matter of universal opinion that the proposed schedule of highway improvements is the most important program of construction work in the country. Thousands of miles of better roads are to be built; billions of dollars will be spent for materials and labor and a very considerable quantity of new equipment will be required with which to do the work quickly and economically. In every state of the Union highway departments and county road organizations are planning the most extensive improvements that have ever been contemplated. The efficient road builder of today uses machines to do his grading, ditching, sewer trench excavating, and paving. One tool —a good sturdy, reliable steam shovel—will perform any or all of these operations, easier, quicker, better and cheaper than could be done by hand labor. Fig. 1 shows a steam shovel reducing a grade.

It is scarcely saying too much to assert that no other machine has so greatly influenced road grading methods and helped along the movement for the general improvement of our highways systems. With a little Marion, revolving steam shovel, grade reductions have been made practicable, low prices have been filled, dangerous curves and narrow trails have been eliminated, and all at less expense and in shorter time than was ever possible before.

Scarcity of labor lately has been the bugaboo of road contractors and highway boards, but many have found a way out and have built their roads by using the steam shovel for the heavy work and utilizing available labor

FIG. 1. REDUCING A GRADE WITH A MARION SHOVEL. The Wagons are Kept Loaded and the Shovel Sets the Pace for the Entire Outfit.

for the small odd jobs that alone needed human labor.

Steam Shovels Are Economical on Shallow Grading

Ten years ago the contractor with a shovel who thought he could profitably do work shallower than 2 or 3 ft. was a general object of mirth; today there are scores of shovels that are making good profits for their owners on street paving work no deeper than 9 ins. As a matter of fact, several cases of 6-in. shovel grading have been reported, and while these are exceptional cases they prove the point that, wherever the amount of work justifies, the small revolving shovel becomes the contractor's "right hand man."

When it comes to excavating sewer trenches, see Fig. 2, it is difficult to get a machine that can do the job better, considering it from all angles. These little shovels will dig almost any kind of material from common top soil to blasted rock and boulders. They will dig in almost any

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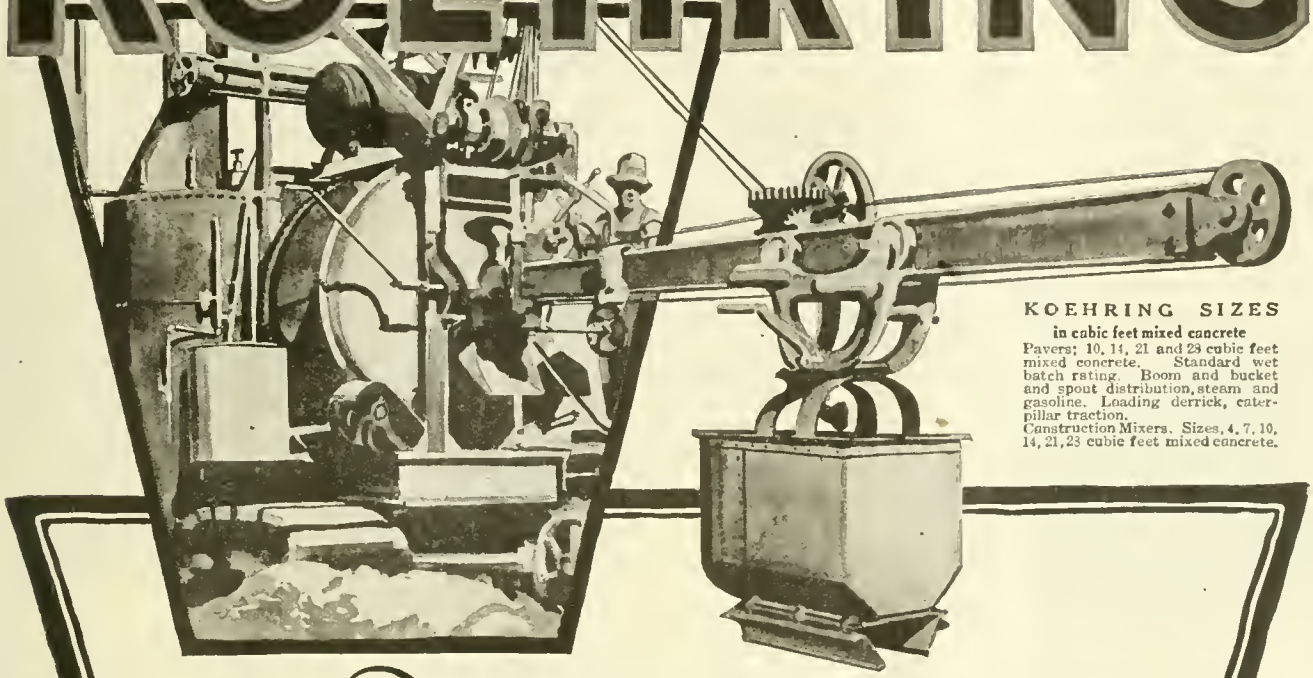

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Loading derricks to lift batch boxes from cars or trucks to charging skip. Koehring Mixer Loader when materials are placed on sub-grade cuts out all wheelers.

Koehring Machine Company
Milwaukee Wisconsin

length and width, being limited only by the length of boom and dipper handle, and this of course can be varied within a considerable range.

The latest development of the steam shovel is seen in the new "Marion" Model 21, ¾-yd. revolving type, see Fig. 3. This model incorporates features that never before found place in this type of shovel but proved, by practical experience in the hands of users, to be highly desirable. Hoisting engines, 6 x 6 ins. larger than heretofore seen in this type, provide an abundance of power. The boiler is likewise of larger capacity insuring ample steam volume and pressure. Rigid tests must show all Marion boilers able to stand a hydrostatic pressure of 1½ times the allowable pressure. They are most carefully built to conform to all state laws and the A. S. M. E. boiler code. Attention has also been given to the reduction of friction through the use of larger bearing surfaces. All this means increased power at the dipper.

Good steam shovels are usually long-lived, but extra precautions have been taken to make this new "Marion" even more rugged than the former models in this class. All parts subject to extreme wear or strain are made of steel, specially designed and heat-treated. Vital parts are all readily accessible so that inspection and adjustments may be made easily. All bevel propelling gears are manganese steel, a distinct innovation on shovels of this type.

Greater speed in digging and rotating is obtained by reducing the gear ratio and the machine is more easily and more speedily handled by the operator through the use of combination throttle and friction lever. There is

FIG. 2. THIS STEAM SHOVEL HAS DUG THE TRENCH, IS NOW LOWERING THE LARGE PIPE INTO PLACE AND WILL LATER BE USED FOR BACK-FILLING THE TRENCH.

an unobstructed full opening at the top of dipper giving a greater digging angle and increasing the effective pull at the dipper.

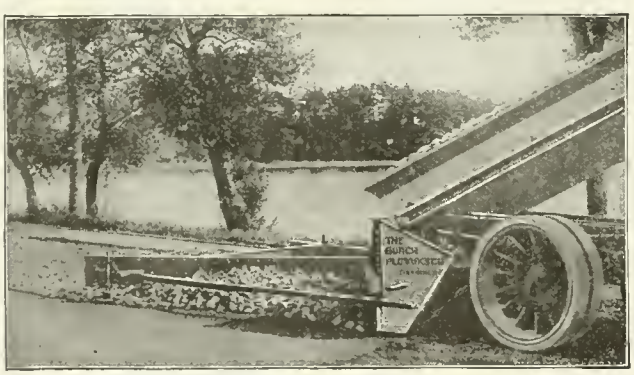
The comfort of the operator has also been considered —no negligible feature these days. The house has fold-

FIG 3. THE LATEST MARION, MODEL 21, ¾-YD. REVOLVING SHOVEL.
A Practical Machine for Street and Road Grading, Trench Excavating and General Construction.

ing doors that completely enclose it when the shovel is not in use, but the doors may be folded back and the front of the house opened when so desired.

TWO MEN DO WORK OF FIFTEEN WITH NEW EXCAVATOR AND LOADER

Machinery that is capable of doing the work that was formerly done by hand labor is saving the day for the contractor. The conditions of the present labor market would probably mean the utter cessation of all building



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Not only does the **Burch** way do the work with less help, in less time and with less expense, but it prevents loss and waste of material and does a better job than any gang of expert workmen ever did. With a **Burch Stone Unloader** and a **Burch Stone Spreader** in operation, you can positively save the wages of 10 to 12 men.

Let us tell you how and why. Write us today for interesting information regarding them and names of successful contractors using them.

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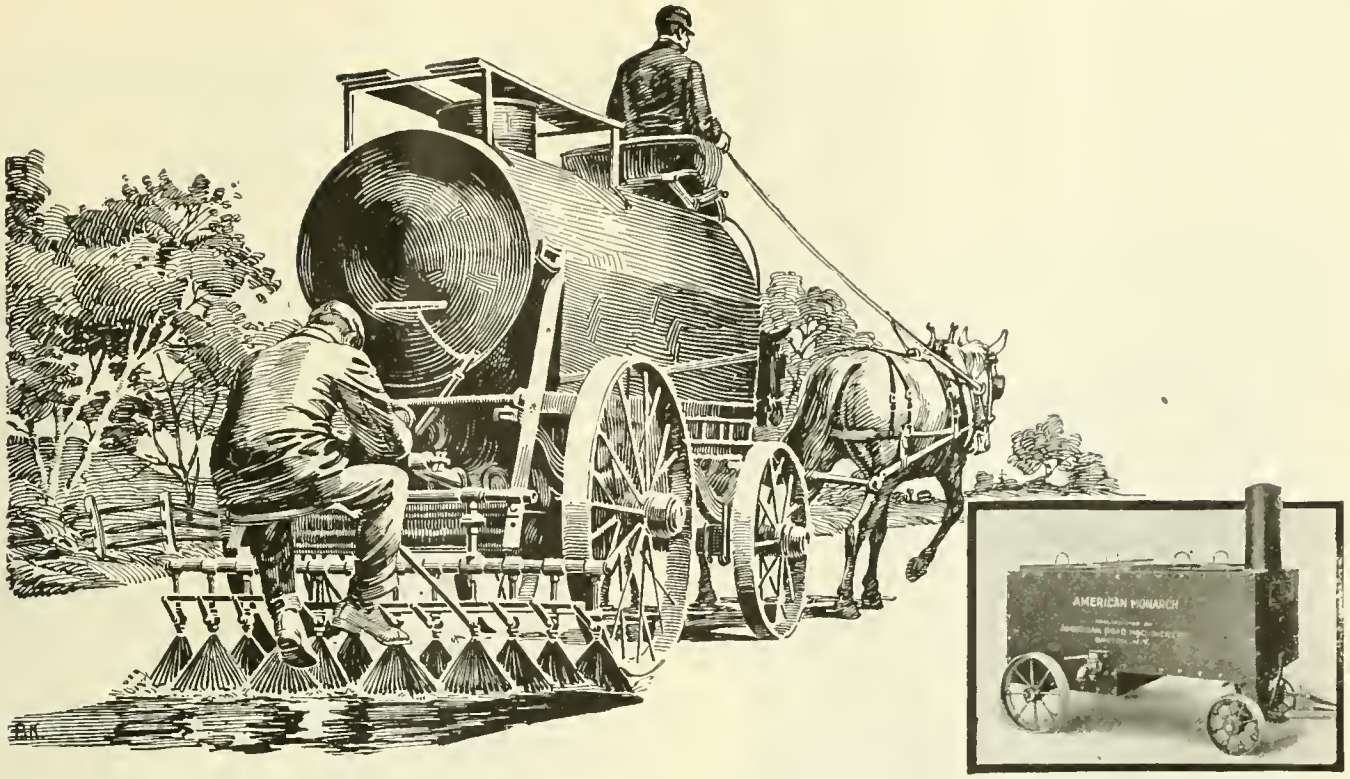

Road Oiling Machinery

In building roads or applying dust layers and preservatives, the method used is just as important as the selection of the proper materials.

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Illustrated above is the American Monarch Distributor designed for applying light and medium grade materials under pressure. It has a 600 gallon, sheet steel tank, with asbestos packed riveted joints, equipped with heating and distributing devices and mounted on a platform spring gear truck. We also mount the same tank and distributor on an automobile truck. Insert shows the American Monarch four wheel Heating Kettle.

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and construction activities at any other time. Getting and holding a big gang of men has become quite a problem, but newly developed labor-saving machinery has done a wonderful part in meeting this emergency.

An excellent case in point is presented by Contractor Fred Schultz of West Bend, Wis., and his Smith excavator and loader machine. With this machine and but 2 men to operate it Mr. Schultz is able to do the work of from 15 to 18 hand shovelers under ordinary conditions. In addition to the actual saving of workmen effected, the contractor was relieved of the usual anxiety of holding his gang intact.

THE SMITH EXCAVATOR AND LOADER IN OPERATION.

The excavating and loading machine operates on the drag-line principle, that is, the machine is stationed at some spot which affords a convenient drive for the wagons or trucks and the dirt is drawn up to it by a cable. After the material has reached the machine it is lifted up and dumped into the waiting trucks. The illustration shows the principle of operation. Only two men are necessary to operate it; one man at the machine and the other man guiding the digging slip.

The work done in this particular case is the foundation for the new factory addition to the West Bend Aluminum Works. The material being excavated is wet blue clay, which is being removed at the rate of between 150 and 175 cu. ft. of material per day. This rate is not indicative, however, of the possibilities of the machine, because it was forced to remain idle several minutes between each load to wait for the wagons to carry away the material.

What can be accomplished under ideal conditions was demonstrated by the record established one morning when sufficient teams were available to keep the excavator working constantly. In exactly 3½ hours it excavated and loaded 55 loads, each aggregating 2½ cu. yds., or a total of 143 cu. yds. This is at the rate of over 300 cu. yds. per 8-hour day and shows more clearly just what can be done when the hauling schedule is arranged to keep the excavator and loader busy all of the time.

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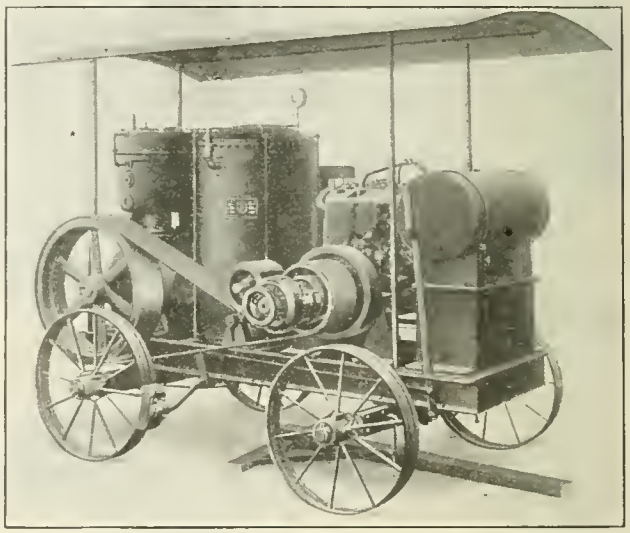
A portable air compressor developed expressly for the contractor has been perfected and placed on the market by the Chicago Pneumatic Tool Co. Each year there is an increasing use of pneumatic tools for road building and construction work necessitating a portable compressor of lighter weight than the Chicago Pneumatic oil or gasoline tank mounted machines, so, in response to the demand, the company has produced this new Class P compressor, here illustrated, to supplement its line of oil and gasoline engine driven portable compressors. The unit is compact and very light in weight.

The air end of this new machine consists of a two-cylinder single acting vertical air compressor having 8-inch diameter by 6-inch stroke, water-cooled cylinders and



THE CHICAGO PNEUMATIC CLASS "P" PORTABLE COMPRESSOR, EXPRESSLY DESIGNED FOR THE CONTRACTOR'S REQUIREMENTS.

plate valves. These valves have been designed for an operating speed of 400 revolutions per minute, and at this speed the capacity is 140 cu. ft. per minute. This compressor being of high speed vertical design combines maximum capacity and minimum weight. It discharges directly into an air receiver having a volume of 10 cu. ft.

The receiver is fastened to the truck by two iron straps placed at right angles to each other over the top of the receiver and bolted to two steel angle sections which form an integral part of the truck.

The power end of the outfit consists of a verticle four-cylinder gasoline engine having 4¾-in. diameter by 5-in. stroke water-jacketed cylinders. This engine operates at 1,000 revolutions per minute, and is fitted with a friction clutch pully of proper size to drive the compressor at its rated speed. The ratio of speed reduction, together with the short belt drive and the use of the idler effectively eliminates belt slippage with its resultant transmission losses and belt troubles. The fuel consumption when operating at full load is 25 pints of gasoline per hour.

Both engine and compressor are thoroughly cooled by a positive system of circulation. The cooling water is forced through the jackets and a high grade efficient radiator by two centrifugal circulating water pumps one driven by a belt from the compressor shaft, the other by gears from the engine shaft. A rapidly revolving fan operating directly behind the radiator draws through it a blast of cool air which extracts the heat. This system of cooling requires but little water and is simple and reliable in operation.

The Michigan Jr. Gravel Screener and Loader

A Machine that will take the Gravel out of the Pit or Pile, Screen out the Sand and Stones and Load the Gravel into Wagons or Trucks.

The machine runs up and down the side of the pit or pile on a track and takes off a slice of about four feet at each time over the track. After going along the track once, the track is moved over and the loader returned along the side of the pit or pile.

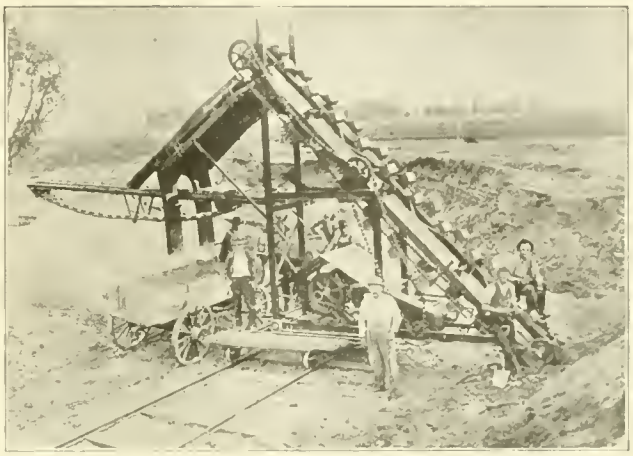
The Screener and Loader is self-contained, furnishing its own power, and has an attachment on the screen that prevents it from clogging up with clay, clods, etc.

The machine has an elevating capacity of *one yard per minute* and, usually, the only operating expense is salary of three men.

One man operates the machine and two men break down the embankment.

The sand and stone are conveyed 20 feet away and do not have to be moved. Machine operates up and down the track as well as in and out of the embankment under its own power. It is all steel, and engine enclosed.

Easily moved from one pit to another. *Saves $30 to $50 per day* in expenses. It is the machine that saves and makes money in handling gravel.



Calhoun County (Michigan) owns aod operates four of these machines, and contractors own three others, making seven in the County.

For further particulars write to

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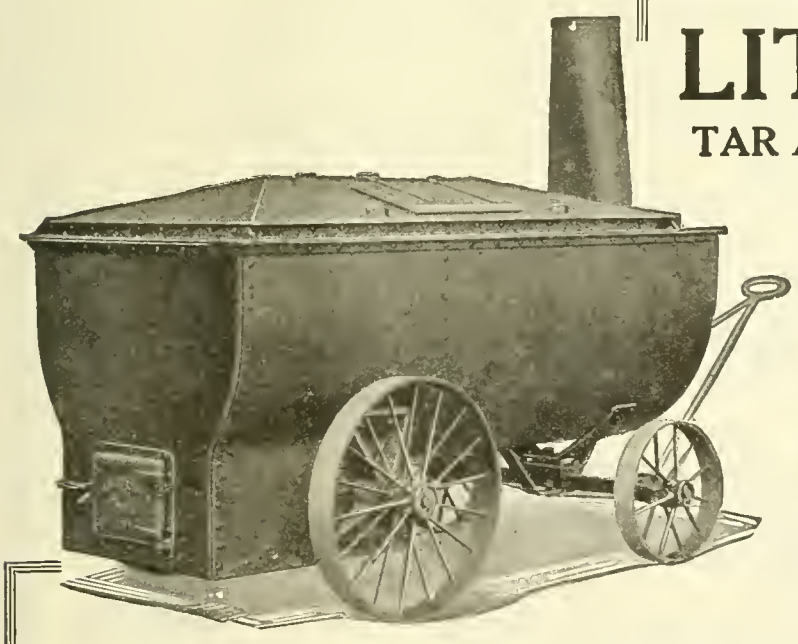

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TRADE NOTE

Mr. M. C. W. Boyd has resigned from active engagement with The Heltzel Steel Form and Iron Co., of Warren, Ohio, as General Manager of Sales. He has not severed his connection with the Heltzel Company, but henceforth will be actively engaged as General Manager and Treasurer of the Good Roads Corporation of Kansas City, Mo., manufacturers of high pressure atomizing road oilers, power flushers and power spreaders of tar and bituminous materials. The factory and general offices of this corporation are at 14th and Chestnut Sts., Kansas City, Mo. Mr. W. J. Savage has been appointed Director of Sales of the Heltzel Steel Form and Iron Co., in charge of the Steel Form Department. Mr. E. V. Ford will be in charge of Parrish Templates and Finishing Machines. Mr. Savage has been with the Heltzel Company for three years, with the exception of one year spent in France in the military service.

CONTRACTS AWARDED

ROADS AND STREETS

Ariz., Tucson—Robert McKay, awarded contract for constructing 11 miles gravel surfaced road from Gunsight toward Tucson, at $66,000.

Ark., Searcy—J. A. Burt, Gunnison, Miss., awarded contract to constr. 17 miles gravel road, White County, at $300,000; 47,045 cu. yds. gravel.

Ark., Springdale—J. H. McIlroy, awarded contract to construct 7 miles Elm Springs Rd., at $170,951.

Cal., Los Angeles—Wm. Liddington, 420 E. 60th St., awarded contr. for impvt. of Lockwood St.—Hoover St. to Virgil Ave.—at $4,525; also contr. doe impvt. of Seaside Ave.—Altoona to Samples Place—at $99,996.

Cal., Redwood City—Hutchinson Co., 44 17th St., Oakland, awarded contract for improving Redwood Highlands Dist., including oiled macadam paving, cement curbing, conc. guttering and grading, at about $54,000.

Cal., Santa Cruz—Marshall & Baker, 2967 Avalon Ave., Berkeley, awarded contract by Bd. Supvrs. Santa Cruz for grading and concrete paving 7.09 miles of road betw. Soquel and Aptos, at $197,861.

Fla., Mayo—Finley Method Co., Heard Bldg., Jacksonville, awarded contract to construct 30 miles hard surface road; $200,000 available.

Fla., Miami—Municipal Constr. Co., McHagee & Sons and J. F. Morgan Constr. Co. awarded contract to pave streets at $121,000.

Ida., Boise—Siems & Carlson, Spokane, awarded contract for grading 8 miles Greer-Fraser Hwy., at $184,008.
Co. awarded contract for paving White Pole Rd. from west end of city to Dallas County line, at $202,736.

Iowa, Rockwell City—Following contracts for graveling Calhoun County Rd., aggregating $150,000, awarded: Snaler Constr. Co., Ackley, Iowa, 30 miles; A. R. Eno, Havelock, and Hammondtreet & Pilmer, Des Moines, 8 miles surfacing.

Kans., Oskaloosa — Hallet Construction Co., Kansas City, awarded contr. for constr. of 10.75 miles monolithic macadam road in Jefferson County, connecting Oskaloosa and Williamston, at $348,115. Some 40 conc. culverts and 2 steel bridges included in contract. Roadway will be 18 ft. wide. Specfs. call for 5½ miles crushed rock, 2½ ins. screenings, finished with oil and asph. surface.

La., New Orleans—Francis C. Constant, Alexandria, awarded contract for 10½ miles of road in Madison Parish, at $133,192; Andrew Hero, contr. for 2.80 miles hwy., Jefferson Parish, at $24,500; Cope & Williams, Orleans, contr. for 3.25 miles rd., St. Bernard Parish, at $13,280.

La., St. Bernard—Cope & Williams, New Orleans, awarded contract by State Hwy. Dept., New Orleans, to construct 3.25 miles road betw. New Orleans and Pointe a la Hache, at $73,280.

Mich., Lansing—J. A. Slatterly, North Branch, awarded contract by State Hwy. Dept., Lansing, for grading, draining, surfacing 6.937 miles State Trunk Line Rd., 38-3, 16 ft. wide, Lapeer and Tuscola counties, at $118,475.

Minn., Brainerd—Ed. Johnson & Co., Superior, Wis., awarded contract for Job 2001, State Rd. No. 2, at $80,563.

Mo., St. Joseph—Metropolitan Paving Co. awarded contract for paving Sparta Rd. betw. St. Joseph and Faucett, at $464,205.

Mont., Livingston—C. T. Heaton Construction Co., city, awarded contract for 6-in. plain concrete pavement, at $414,000. Same company also received large sewer contract.

Nev., Carson City—J. H. Causten, Lovelock, Nev., awarded contract for grading and graveling 27.81 miles state hwy.—Zola to Mill City—Pershing Co., at $94,289.

N. C., Asheville—Asheville Construction Co. awarded contract to surface 8 miles Leicester Road, at $218,000.

N. C., Salisbury—R. M. Hudson Co., Atlanta, Ga., awarded contract to pave 2 miles of streets, at $150,000.

Ohio, Jefferson—T. P. Fitzgerald, 306 Main St., Ashtabula, awarded contr. for grading and paving 6.48 miles Ashtabula-Austinburg Rd., at $171,666.

Mont., Butte—Marco J. Medin & Co., Butte, awarded contract to constr. Butte-Anaconda roadway, 9 miles of paving, solid concrete, 8 inches thick in center and 6 inches at the outer section, at $209,518.

Pa., Harrisburg—R. G. Collins, Jr., New York, awarded contr. for constructing State Hwy., Lycoming Co., at $1,083,057. Road runs through Jackson, Lewis and Coganhouse twps.

Pa., Williamsport—Busch & Stewart, city, awarded contr. for constr. of 29,000 ft. hwy. from Cogan Sta. to Trout Run, at $413,000.

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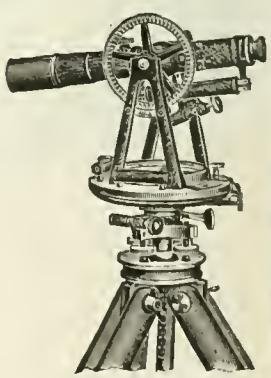

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EDITORIALS

WATER WORKS ISSUE

Special attention is paid to water works matters in this issue, primarily because of the annual convention of the American Water Works Association at which this number will be exhibited. More than the usual amount of space is devoted to this subject, for this issue, and a number of very interesting and practical water works articles are presented. These articles will be of great interest to water works men, naturally, and they are also of unusual interest to the general reader. The Water Works section provides municipal and county engineers, generally, an opportunity to note the matters now occupying the attention of their contemporaries in the water works field.

BIND YOUR COPIES OF M. & C. E.

The present number of this magazine completes the fifty-eight volume, and a complete index to this volume will be published in the next issue for the convenience of those who make a practice of binding their copies. A great many of the readers take this means of preserving their magazines for future reference. The practice is a good one and every interested reader would do well to adopt it. The work is inexpensive and it can be done in almost any locality.

The publishers are often reminded of the wisdom of binding the magazine by letters from subscribers asking for references to articles on various subjects, and asking for back copies containing matters of present interest to the individual. The point is that workers in this field move about more or less, not only from place to place, but from one department to another, and from city to county service or vice versa. Thus the county engineer of today may have less than an academic interest in water works matters, but if a political upheaval lands him in a city water department his interest will quickly change. He will do well to preserve the best of current literature on all municipal and county engineering subjects so as to have good backing when he makes a change in his work.

Oftentimes we are requested to furnish back copies; usually we can do so but not always. Every issue of this magazine is worth preserving because so many of the articles are written for our exclusive use and do not appear elsewhere. No matter what other journals may be read this one should be preserved for it contains much of permanent value. We suggest that those who have not bound their copies before adopt the practice at this time.

WHEN A MAN WRITES A GOOD ARTICLE

When a man writes a good article for a magazine of this character it is the practice of some readers to write him complimenting him on his presentation and thanking him for making a useful and interesting contribution to the literature of the profession. Such a practice, if generally observed, would operate greatly to enrich such literature.

Very often readers write to the editor indicating that they have found much satisfaction in reading this or that article. Such letters are always welcome as they indicate that the magazine is producing the character of material the readers want. When noted, these letters are often forwarded to the contributor.

While publishers realize that it is only the occasional man who will occasionally write such letters, the man who writes but one article a year, or in several years, may fail to understand silent approval. He is not sure he has been of service unless told so.

Many engineers could write interesting articles if they would and there is no better way to encourage the writing of more good articles than to express appreciation of those published. Engineers are often slow to write, fearing that what they have to offer will be criticised adversely. We have not found engineers especially critical of the writing of their contemporaries in recent years. The engineer is growing broader in every way and does not indulge narrow prejudices as he did ten years ago. Then, many engineers never wrote and were inclined to criticise and ridicule those who did. The result was that only the monumental works were described and matters of ordinary interest were ignored by contributors as there were too many able and willing, not to say anxious, to criticise such writings. After one unhappy experience many never got up courage to write a second article.

But there has been a change in this matter, we confidently assert. Anyone who is public spirited enough to write today, is sure of respectful attention. Knowing that readers are appreciative we hope they will take the time to write to authors of good articles along the lines here suggested. This is a constructive practice.

DESIGN OF BITUMINOUS PAVEMENTS OF FINE AGGREGATE

By R. Keith Compton, Chairman and Consulting Engineer, Paving Commission, City Hall, Baltimore, Md.

This article is intended to cover in a practical manner, important factors and points in the design of bituminous pavements of fine aggregate, so that the layman or untrained engineer may not be misled in believing that any pavement of any design or type is good enough. The writer is convinced that each of the standard types of pavement has its place, but it would be foolish to take the stand that any particular type can be laid anywhere, under any and all conditions and produce good results. A bituminous pavement of fine aggregate is commonly known as sheet asphalt, its surface course consisting of asphalt cement mixed with carefully graded sand and fine mineral filler, such as limestone dust or Portland cement. When stone is added to the mixture, it then approaches the coarse aggregate.

Where Sheet Asphalt Pavements Are Applicable

For all types of motor traffic, generally speaking, a properly designed and constructed sheet asphalt pavement more nearly approaches the ideal than any other type. It will sustain a very heavy amount of traffic, preferably quick moving, light or medium loaded vehicles; for instance, such traffic as prevails on many business streets. It is not claimed to be particularly adapted to slow moving, dense traffic; some block pavements will outlast it under such conditions. It must have some traffic to cause the kneading action necessary for it to retain those properties which constitute its life and durability. Therefore, before deciding on this type of pavement or any other, the engineer must consider the extent, volume and character of traffic, the grade of the street, width of paved driveway, whether or not street railway tracks exist, character of section to be served, whether business or residential; whether noise is a factor, and it generally is, and whether or not the street is in close proxinity to a water front as bituminous pavements will not withstand moisture; they must have a chance thoroughly to dry out. Generally speaking, an 8 per cent. grade is the maximum for sheet asphalt on a heavy traffic street. For light traffic it has been laid with success on grades up to 12 per cent. It is an established fact that this type is most slippery on light grades, say under 2 per cent., during bad weather conditions, when the surface is covered with a thin film of slimy mud, with insufficient rainwater and grade to cause self-cleansing.

VIEW OF MULBERRY STREET WEST OF HOWARD STREET, BALTIMORE, MD.
Paved with Sheet Asphalt on 6 in. Concrete Base with Brick Gutters. Completed in 1914.

If, after a proper application of the above factors and bearing in mind the limits of endurance, sheet asphalt is decided upon as the pavement to install, we must then consider the design, which procedure is about as follows:

Base

A bituminous pavement has little, if any, inherent strength, therefore, we must depend upon its base, the character and thickness of which must be selected with care, depending mostly on the character and volume of traffic but also largely on the character and dependability of the sub-grade. Various kinds of base or foundation have been used; old pavements such as cobble, brick and granite block in place, have been used as such, by simply adding the binder and wearing surface. Practical experience has proven that this is not first class construction, although it has been completely successful in many instances. Its success depends entirely on the condition of the old pavement used as a base when the top is installed and extreme care must be used in all phases of the construction. Old macadam, well compacted from years of traffic, makes a very suitable foundation for this type of pavement when traffic is medium and fast moving, as on state roads not main arteries, and also on residential streets, but the same precautions must be taken.

The most desirable and the most dependable foundation for all pavements is concrete of a 1-3-6 mixture and from 4 to 8 ins. in thickness, depending on traffic and soil conditions, 6 in. being the usual standard. The subgrade should be finished to exact section and thoroughly drained and compacted before the foundation is laid.

Binder

The writer still adheres to the old-fashioned notion that a binder course is necessary and desirable for the following reasons:

A. The top of the concrete should be rough and is often uneven. The binder evens this up so that the wearing or top course can be of a uniform thickness.

B. It acts as a cushion between top and base, thus protecting to some degree at least, the top from the impact.

C. It protects, to a very large extent, the top from dampness, which in some soil comes up through the base.

D. It acts as a bond between top and base, thus preventing "moving" or "shoving."

Other reasons can be given for its use but these are the principal ones.

The standard thickness of the binder course is us-

ually 1½ ins. and it can be "open" or "close"; most engineers prefer it moderately close complying with specifications about as follows:

> The binder stone shall be hard, clean stone, free from any particles that have been weathered or are soft, all of which shall pass a 1 in. screen; 85 per cent. of the stone shall pass this screen in its longest dimension, and of the remaining 15 per cent., no piece shall have a larger dimension than 1¼ in. At least 65 per cent. of the stone passing the 1 in. screen to be graded in size from ⅞ in. to ⅜ in. and after passing the heating drum, shall contain not less than 15 per cent. nor more than 30 per cent. passing a ten-mesh sieve, so as to produce after the asphalt is added and then laid, a binder that in the judgment of the chief engineer will be a compact mass with a uniformity of voids, and that is suitable for the street on which it is to be laid.

The percentage of bitumen should be regulated in accordance with the mesh, composition and character of the stone aggregate, the minimum amount being 4½ per cent., but in any event sufficient to hold the particles of aggregate together. Soft or fat spots should be avoided. The binder should come to the work sufficiently heated, so that it can be spread, raked and rolled to a solid, uniform surface, parallel with, and the thickness of the top course below, the finished surface.

Characteristics Mineral Aggregate	Class 4 Light Traffic	Class 4 Heavy Traffic
	Per Cent. of Mineral Aggregate	
Passing 10 mesh retained on 20 mesh	8	3
Passing 20 mesh retained on 30 mesh	10	5
Passing 30 mesh retained on 10 mesh	12	8
Passing 40 mesh retained on 50 mesh	15	14
Passing 50 mesh retained on 80 mesh	27	26
Passing 80 mesh retained on 100 mesh	9	15
Passing 100 mesh retained on 200 mesh	10	14
Passing 200 mesh	9	15
Total	100	100
Per Cent. of Bitumen in Mixture	10	11

VIEW OF CHARLES STREET NORTH OF MULBERRY STREET, BALTIMORE, MD.
Paved with Sheet Asphalt on Sides on 6 in. Concrete Base. Vitrified Block in Tracks with Wood Block Liners between Asphalt and Rails. Completed in 1915.

Top or Wearing Course

As stated, elsewhere, the wearing surface is composed of carefully graded sands and fine mineral filler, such as limestone dust or Portland cement, with sufficient asphaltic cement added to hold the particles together. The mineral aggregates really carry the traffic, the asphaltic cement simply acting as a binder to hold them together. The selection of both, however, is important, as upon these will depend the utility of the pavement if it is really to perform the functions for which it is intended. Ideal sands are frequently very difficult to obtain in some localities. Washed sand is preferred to bank sand because the latter so often contains small quantities of loam which will "ball" and weaken the mixture. One often has to take several sands and mix them before a satisfactory mesh composition can be obtained but a typical grading is given below, taken from Brochure No. 11 of the Asphalt Association:

The amount of bitumen or asphaltic cement depends on the amount of traffic and the sand grading; the finer the sand the more asphaltic cement, as there are more surfaces in the aggregate to coat. No set rule can be followed; one must study the local sands available, analyze and if necessary mix them so as to bring the finished mix, if possible, within the bounds of good practice.

Penetration

The penetration of the asphaltic cement is very important, and recent practice shows an inclination to use a lower penetration than formerly as the addition of oil drippings from motor traffic shows a tendency to soften the surface. Therefore, by lowering the penetration when the pavement is constructed, the subsequent addi-

tion of oils from that source will bring the consistency to about the desired point, and prevent what otherwise would cause "moving" or "shoving."

The following is a typical penetration grading, copied also from the Asphalt Association Brochure No. 11:

Characteristics Asphalt Cement		Light Traffic	Heavy Traffic
Traffic	Climatic Temperature	Penetration at 77° Fahr.	
Light	Low	55	..
	High	45	..
Heavy	Low	..	45
	High	..	40

It is also very important that the wearing surface reach the street heated to such a degree that it can be readily raked and rolled to produce a compact, smooth surface of uniform thickness.

Inspection

It is necessary to have expert, but practical inspection, both at the plant and on the street. Many highway departments maintain a laboratory in connection with the inspection system, so arranged that samples from both plant and street can be analyzed and checked one against the other. With a proper system of inspection, poor materials and workmanship can be avoided and it can be determined, within a very short period, whether or not the work is being executed in accordance with the contract and specifications. Such a system can be made very valuable to both principals.

Gutters of Vitrified Block

Gutters of some hard, durable material, such as vitrified block, are desirable and at times absolutely necessary, particularly where there is any amount of surface drainage. Where all surface drainage has been eliminated they are necessary on grades under 2 per cent., but they are desirable on all bituminous construction for two reasons:

Gutters are for the purpose of collecting drainage and consequently the space next to the curb is generally damp, particularly on flat grades, owing to the collection of debris, etc. Furthermore, it is not always feasible to roll in close proximity to curbs and the existence of a gutter 12 to 18 in. in width permits a more accurate cross section and contour, and also permits the accomplishment of better compression and more expert handling of the roller.

Railway

More failures in bituminous construction occur adjacent to the tracks than anywhere else, due to concentration of traffic within the track areas, but more generally to poor track construction. Therefore, the railway construction should be of the best rails of the latest pattern, on sound ties, brought to good line and surface. Ties should be on a foundation of either rock ballast or concrete. Where the paved drive is of sufficient width as not to cause concentration of traffic, bituminous pavement can be laid within the track area, in which case liners of hard material such as granite should be laid against the rails. This also permits access to joints in case repairs are necessary. In case there is a decided concentration of traffic, the track area between extreme outer rails should be paved with some hard material such as granite or vitrified blocks.

ASPHALT CEMENT QUALITIES AND TESTS NEEDED IN SPECIFICATIONS FOR SHEET ASPHALT AND ASPHALTIC CONCRETE PAVEMENTS

By J. W. Howard, C. E., E. M., Consulting and Testing Engineer of Pavements and Roads, 1 Broadway, New York, N. Y.

Many city, county and state engineers, and paving contractors, desire to know the qualities an asphalt cement must have and the laboratory tests it must meet, to be good and reliable for use in making sheet-asphalt and asphalt-concrete pavements; without respect to brand name or the crude or raw materials from which it is manufactured.

Just as the qualities and tests for good Portland cement are now well established, so are those for good asphalt cement for use in compounding hot paving mixtures for sheet-asphalt and for asphalt-concrete wearing surface layers to go on the various kinds of good pavement bases or foundations; sheet-asphalt being generally made of suitable sand, powdered limestone filler and asphalt-cement; asphalt concrete being of the same three ingredients, with suitable crushed stone added.

The following is based on a practical experience of 30 years in laying, and making laboratory tests of pavements and pavement materials; before, during and after successful use:

First. It is best to state the basic qualities good asphalt-cement must possess, because it is this cement which goes into a pavement mixture and not the separate or single raw material from which an asphalt cement is made. All asphalt cements are artificial products, either by refining separate materials and mixing them, or by distilling or refining a raw or crude material.

The basic qualities of every asphalt-cement for hot-mixed asphalt composition pavements are:

1. Adhesiveness or cementing strength.
2. Waterproofness or freedom from injury by water.
3. Immutability, or freedom from deterioration from exposure to sun and air.
4. Cohesiveness.
5. Ductility.
6. Flexibility or pliability.
7. Malleability or yielding to shock without cracking.
8. Consistency or softness (penetration) at mean weather temperature (77 F.), proper for the kind of pavement, traffic and climate.
9. Minimum allowable susceptibility to softening or stiffening from extreme weather temperatures.
10. Purity or high percentage of bitumen or cementing ingredient.
11. Freedom from impurities of vegetable or other deleterious matter.
12. Freedom from injury by the degrees of heat necessary from melting and use in making pavement compositions or mixtures.

Second. While the above are the basic qualities the asphalt cement must possess, the following are the chemical and physical tests which the author makes in his laboratory to determine if any asphalt cement, without respect to brand or method of manufacture, is fully suitable for use in making any asphalt pavement coming

within the two types named; sheet-asphalt and asphalt-concrete, within each of which there are several kinds.

The tests of asphalt-cement, which can be safely incorporated in specifications for (hot mixed) sheet-asphalt, including its binder-course and asphalt-concrete pavements, are as follows:

The asphalt-cement used in the pavement shall have the following qualities and meet the following tests:

(a) It must contain no water, coal or gas tar or their derivitives.

(b) It must be homogeneous and uniform.

(c) It must not be affected by water or contain any substance soluble in water, and thus be waterproof. The test for waterproofness is to put a very thin hot coating or film on a clean, dry glass plate and immerse one-half of the plate and film in clean water in a covered jar for two or three weeks and then observe, by withdrawing the plate, if the immersed portion of the asphalt-cement, compared with the non-immersed, dry part, has become grey or softened or injured by the water.

(d) It must be ductile to the extent that at 77 degrees F. it can be stretched at least 40 centimeters; after having been formed in a mould so that its central cross section is 1 square centimeter, as per specifications of Washington, D. C., New York, etc.

(e) Its specific gravity at 77 degrees F. must be at least 1.01.

(f) Its penetration, or degree of softness, at 77 degrees F. must be between 35 (0.35cm.) and 75 (0.75cm.), according to the other materials used in the pavement mixture, the climate and weight of traffic and as directed for each pavement and street or road; low penetration for warm and high penetration for cold climates; low for heavy and higher for light traffic; higher penetrations for asphalt-concrete than for sheet-asphalt pavements. The test for penetration is to be made with any proper penetration apparatus; using a standarized No. 2 needle, under 200 grams weight for 5 seconds, measuring the depth of penetration of the needle into the asphalt-cement.

(g) Its freedom from volatile oil and safety for heating for use must be tested by the flash test, made with the asphalt-cement in a metal or porcelain crucible about 3 ins. in diameter across the top and about 1½ ins. deep, with the thermometer bulb in the melted asphalt-cement. The flash test is when a slight flash of fire, with a slight popping noise, occurs on the surface of the slowly heated asphalt-cement, when a small flame or lighted match is applied. The temperature at which the asphalt-cement flashes must not be below 450 degrees F.

(h) Its stability against injury by heat in use and by weather action on the pavement is determined by exposing 20 grams in an open tin can between 2 and 2½ ins. diameter, 1 to 1¼ ins. deep, exactly 5 hours, in hot oven air, at 325 degrees F., and the asphalt-cement must not lose more than 3 per cent. of its original weight.

(i) The penetration or degree of softness of the residue at 77 degrees F., after test (h), must be at least 60 per cent. of its original penetration (test f); that is test (h) must not harden it more than 40 per cent.

(j) At least 98 per cent. of the pure bitumen of the asphalt-cement must be soluble in carbon tetrachloride at about 77 degrees F., or room temperature.

(Note. The bitumen (or purity) of the asphalt-cement, is the portion by weight soluble carbon bisulphide. It ranges from about 70 per cent. to 99.9 per cent. in good asphalt cements, meeting all the tests of these specifications.)

(k) The purity or pure bitumen content of the asphalt-cement used in any one pavement, as determined by solubility in carbon bisulphide, must be uniform and not vary more than ½ of 1 per cent. up or down.

(l) The asphalt-cement must have an average cementing strength (three tests) of at least 25 lbs. per sq. in. (Howard or equivalent method), when made into a hot compressed briquette composed of standard Ottawa sand (of 20-30 mesh size grains), 90 parts by weight and 10 parts of the approximately pure bitumen of the asphalt-cement (or asphalt cement itself when above 99 per cent. pure bitumen). These briquettes have the same shape and size as the standard Portland cement briquettes of the American Society of Civil Engineers and must be broken by tension at 77 degrees F. in any briquette cement-testing apparatus used for Portland cement tensile tests.

Where the specifications contain the above twelve tests, and no requirements under the guise of tests are added to identify, limit or wrongly favor special brands, and where the twelve proper tests are applied during use of an asphalt-cement, then good pavement, as far as the asphalt-cement is concerned, will result.

No asphalt pavement has been condemned for failure of the asphalt-cement where records show that the above tests were met. It must be remembered that asphalt-cement is only from about 8 to 11 per cent. of asphalt pavement compositions. Care must also be used to test and use proper gradation of the mineral aggregates. Over heating, lack of compression, laying too cold, open or porous binder layer instead of dense or close binder (under asphalt pavement surface layer), lack of good foundation, etc., all these are causes of failures and must be avoided in order to secure good, durable asphalt pavements of all types.

THE REVIVING INTEREST IN INLAND WATERWAYS

By W. J. Sherman, Consulting Engineer, 618 The Nasby, Toledo, Ohio.

How often do we hear that the American railway system has completely broken down? Claiming that the fault lay with the owners, the Federal government, early in the war, took over the railways during the emergency period.

Government operation was a colossal failure and the most ardent champion of government ownership now seems willing to admit it.

Back in the hands of the owners the railways are still unable to meet the transportation demand. It is not the purpose of the writer to discuss the causes of the failure of the American railways to function properly when most needed. But in passing we should perhaps call attention to the fact that prior to the world war the railways were not permitted to earn enough to provide sufficient equipment, suitable terminals, and at the same time maintain themselves in a good physical condition.

Under government management conditions were worse and employes far less efficient, while the business offered the railways was much greater than normal.

Back once more in the hands of their owners, with physical condition greatly impaired, and the morale of the operating force much below normal, it is universally conceded that the railways cannot meet the demands upon them and supply the transportation which the country requires. Meanwhile, the volume of business seems to be constantly on the increase, the products of the factories must be moved, and the supply of raw materials must be replenished.

Motor trucks and public highway transportation are requisitioned in a vain effort to relieve the congestion. The highways built for light traffic break down under the ponderous motor trucks. The great centers are congested as never before. Ships are waiting for fuel, cargo release or new cargoes in all the ports of the Atlantic and the Great Lakes.

What is the solution of the problem? Some of the best minds of the country are giving attention to this most important subject.

Waterways Are Coming Back

There was a time when inland waterways were in good commercial standing. This was before the time of the railways. Perhaps the golden era of inland waterway prosperity may be said to include the first half of the nineteenth century.

Then came that most wonderful and rapid development of the railway system and the inland waterway traffic began to decay.

Today the indications point to a great revival of interest in water transportation.

The rise and fall of the American Merchant Marine is coincident with the rise and fall of the artificial waterways in the interior of the country.

The revival of the former in accordance with the magnificent program of the Federal government, is turning attention to the wonderful possibilities of the latter

Important Waterway Projects

Already much has been accomplished. Private capital has constructed the Cape Cod Ship Canal at a cost of twelve million dollars. State capital to the extent of one hundred and fifty million dollars has been provided for the construction of the New York State Barge Canal. Abundant government capital is available for canalizing the Ohio river for a 9 ft. minimum channel from Pittsburgh to Cairo, and already two-thirds of this mammoth undertaking has been accomplished.

The state of Illinois has appropriated twenty-million dollars for the improvement of the Illinois river and the completion of an all-water route between Lake Michigan and the Mississippi river. This will provide a suitable connection between the 15,000 miles of navigable channel in the Mississippi Valley, and the 2,500 miles of navigable waters of the Great Lakes.

Other connecting links are considered, including the Barge Canal across the state of Ohio, between Lake Erie and the Ohio river, over one of the several competing routes, and a Barge Canal from Lake Erie to Lake Michigan via the Maumee river and the city of Fort Wayne.

New Orleans is Alert

New Orleans, awake to the revival of river traffic, is expending fifteen million dollars in port improvements, hoping and expecting to provide a suitable outlet for the products of the Mississippi valley, which New York, struggling against congestion and unfavorable labor conditions cannot do.

One of the greatest waterway projects under way at the present time, is that which has for its object the improvement of the St. Lawrence river at international expense, so that ocean-going vessels may enter the Great Lakes.

The St. Lawrence River Project

The importance of this project has been officially recognized by both Canada and the United States, and a joint commission is now engaged in the preparation of a report with recommendation and estimates of cost.

We believe it is safe to prophesy a favorable report from this commission, notwithstanding the bitter opposition of New York and Montreal, for purely selfish reasons.

The commercial interests of 27 states of the middle West are receiving the fostering care of the Mississippi Valley Association. The friendly attitude of this association towards water transportation and the St. Lawrence project, is shown in the following resolutions adopted at their recent convention:

Merchant Marine

We declare for the completion of a well balanced Merchant Marine. We believe in American shipping carried on American bottoms, under the American flag, the ships manned by American sailors. Nothing short of the establishment of such a policy will satisfy the Mississippi valley. The existing Legislative restrictions controlling the operation of American ships, should be modified to permit competitive operation with foreign ownership.

Waterway Development

We commend the general policy of waterway improvement, especially on projects investigated and approved, the preservation of our interior waterways, lake and sea ports, and the construction of canals for commerce representing the very highest development of the country. We insist upon the fullest utilization of natural resources and the development of such resources that lend themselves to final success. Old world competition will demand such cheap transportation as a matter of self-protection. It is advisable that we urge the adoption of the principle of through water and rail rates.

Inland Waterways

We earnestly declare that the next Republican National Convention, and the next Democratic National Convention, be urged to adopt planks in their platforms favoring the development and the speedy completion by the national government, of the various inland waterway projects, approved by the engineers of the war department.

St. Lawrence Canal

We earnestly favor the prompt improvement, by the joint action of the United States and Canadian governments, of the St. Lawrence river so as to admit ocean-going vessels to the Great Lakes; also

the development of the hydro-electric power incident thereto. This improvement making sea ports of our lake ports would double the value of our internal waterways and the whole would go far toward prompt and effective relief from the transportation deadlock under which the central portion of our country now suffers.

Not until the true story of the world's war is told will we realize the important fact played by the network of European canal water courses in the conduct of the war.

In the opinion of the writer the day is not far distant when there will have been developed a grat American system of inland waterways, which is comparable in its importance to the European system which is in operation today.

ESTIMATING LABOR HOUR REQUIREMENTS FOR THREE TYPES OF STREET RAILWAY TRACK CONSTRUCTION

By D. B. Davis, City Civil Engineer, City Hall, Richmond, Ind.

To secure accurate estimates of cost for street railway track construction it is necessary to know the labor hour requirements for executing the different divisions of work.

Generally in single track construction, when the excavation is completed and the subgrade compressed until it is smooth and hard, the ties are distributed and spaced 24 ins. c. to c. upon the sub-grade and the rails spiked thereto. The track, after being lined and leveled, is securely blocked to prevent any displacement by the working force. Then concrete of a wet consistency is mixed and deposited around the ties and brought to within 6 ins. of the top of the rail.

Using a boom and bucket one-bag mixer, when the gravel has been deposited in the proper amount along the site of the work, the following organization will lay on an average of 220 lin. ft. in 10 hours, or it will require 0.40 labor hours per lineal foot.

The organization for concrete base is: 1 engineer mixer, 1 fireman mixer, 1 concrete spreader, 1 handling cement to mixer and 5 shoveling gravel in mixer. Fig. 1

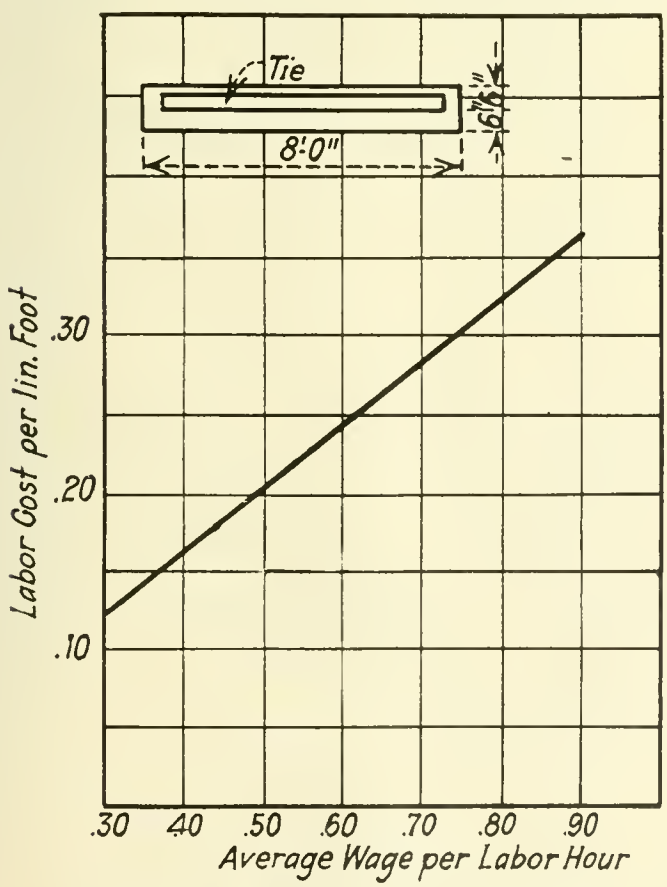

FIG. 1—COST PER LINEAL FOOT TO CONSTRUCT CONCRETE BASE FOR STREET RAILWAY TRACK AT DIFFERENT RATES OF LABOR ASSUMPTION: 0.40 LABOR HOURS PER LIN. FT.

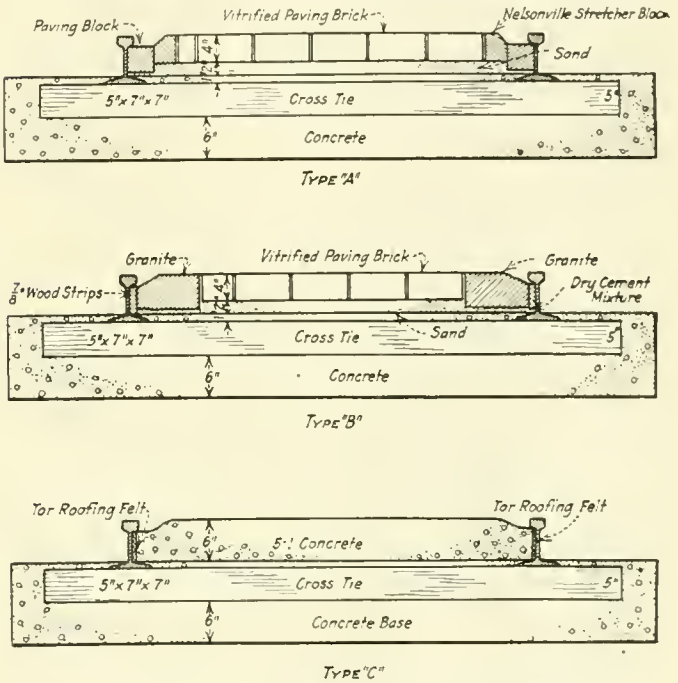

FIG. 2—TYPES OF PAVEMENTS FOR STREET RAILWAYS EMPLOYED IN RICHMOND, INDIANA.

shows the cost per lineal foot to construct the base at different rates of labor.

The types of pavements to be described (See Fig. 2), are: (a) One with a vitrified filler and stretcher block used next to the rail and the intervening space paved with vitrified paving block, the pavement to have a cement filler, type A. (b) One with a beveled granite block used next to the rail and the intervening space paved with paving block, same to be filled with cement filler, type B. (c) One constructed wholly of concrete, type C.

Type A Pavement.

When the concrete base has thoroughly set, sand is leveled off to a thickness of approximately 2 ins. The filler blocks are then distributed along each side, preparatory to being placed against the web of the rail, under which sand is tamped solidly, until the top of the block is against the ball of the rail. The sand cushion after being rolled with a hand roller, is struck off by a templet cut to the required shape, the rails being used as guide strips.

Stretcher block, made by the Nelsonville Sewer Pipe Co., were then set against the filler block, which had been previously laid. The intervening space was then laid and

batted in with vitrified paving block. The defective brick having been removed and good ones put in their place, and the track swept clean of spalls and dirt, the brick were tamped until a smooth surface was attained. The filler, composed of one part Portland cement to one part

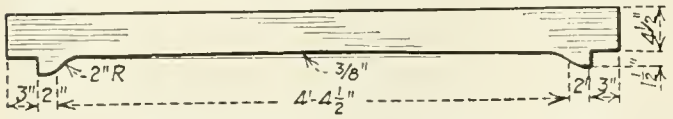

FIG. 3—TEMPLATE USED IN GRADING CONCRETE PAVING BETWEEN RAILS OF STREET CAR TRACK.

clean sand, mixed to a consistency of thin cream, was applied to the pavement by scoop shovels and swept into the joints with brushes.

For this type of pavement it required the following labor hours:

To make sand cushion, set filler and stretcher block and lay and tamp brick in intervening space .....0.264 hrs.
Grouting entire space between rails with cement .....0.048 hrs.

Total labor hours per lineal foot to pave track...0.312 hrs.

Type B Pavement.

The concrete base was constructed as in type A, and the sand was spread in the same manner as before stated. A 7/8 in. wood strip, 4 in. wide, was put against the web of the rail. Then a beveled granite block, measuring about 12 ins. long, 9 ins. wide and 5 ins. thick, was set in a dry mixture of cement and sand, of the proportion of 1 to 3, level with the top of the rail. Special care was taken properly to bed these blocks. The sand was spread and rolled, then cut off to grade by a templet pulled over the rails, a notch having been cut out of the templet to allow it to pass over the block. The space between was then paved, culled and tamped and the filler applied.

For this type of construction it required the following labor hours:

To set and bed granite block.....0.155 hrs.
To make sand cushion and lay brick in intervening space ready for cement grout.....0.166 hrs.
Grouting entire space between rails.....0.060 hrs.

Total labor hours per lineal foot to pave track..0.381 hrs.

Type C Pavement.

In this type of construction the concrete base was swept with brooms as clean as possible and all dirt scraped from the rails. An expansion joint consisting of 4 thicknesses of heavy tar roofing felt was placed against the web of each rail.

Concrete of the proportion of one part Portland cement to five parts clean gravel was mixed to a rather wet consistency and spread upon the concrete base, it being tamped with the back of a shovel to give it a maximum density.

A templet, as shown by Fig. 3, was drawn over the rails until the surface of the concrete was to a uniform grade, free from holes and conforming to the shape of the templet. When sufficiently hard the surface was then gone over lightly with a wooden float until it was comparatively smooth.

For this type of pavement it required the following labor hours:

To mix the concrete in a one-bag boom and bucket mixer, place it on the concrete base and finish it, required per lineal ft.....0.24 hrs.

Fig. 4 shows the cost per lineal foot to construct the three types of paving between the rails for a single track at various rates of labor.

The labor hours required for these various operations were obtained from the writer's experience in Richmond, Ind., and represent work that has been done by energetic, enthusiastic workmen. The proximity which another gang could approach these values would depend wholly on the morale of the workmen and the experience and "pep" of the man in charge.

FEATURES OF ANNUAL CONVENTION OF AMERICAN ASSOCIATION OF ENGINEERS

The outstanding sentiment of the delegates and other members attending the sixth annual convention of the American Association of Engineers, in St. Louis, May 10 and 11, was a desire for building up strong chapters of the association and for decentralization of some of the business functions. It is clear that one great necessity

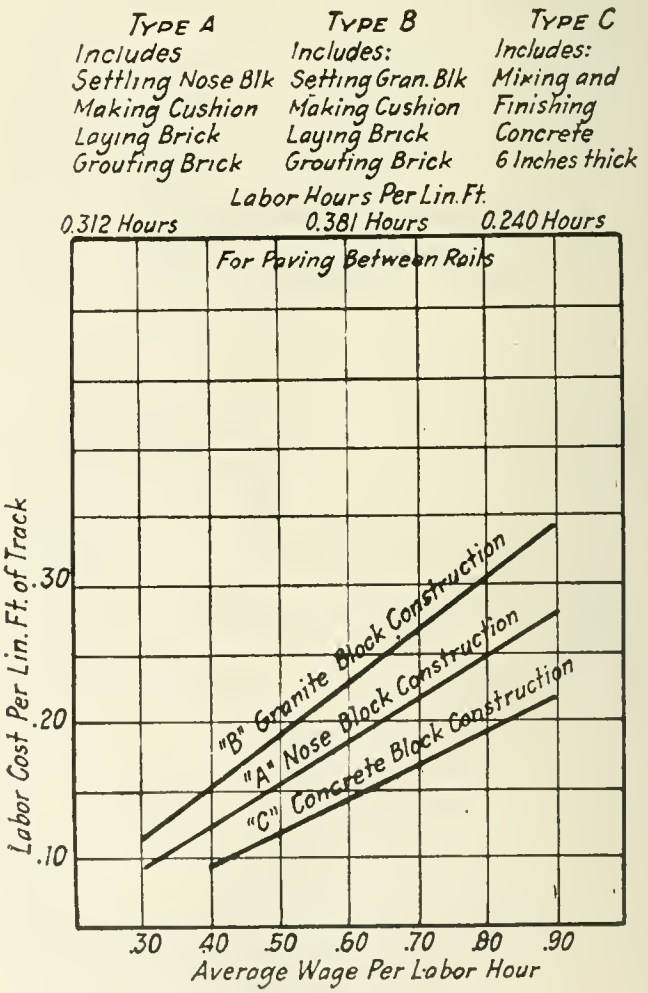

FIG. 4—DIAGRAM SHOWING THE COST PER LINEAL FOOT TO CONSTRUCT THE THREE TYPES OF PAVING BETWEEN STREET CAR RAILS, AS SHOWN IN FIG. 2, FOR SINGLE TRACK, AT VARIOUS RATES OF LABOR.

in an association of engineers is the direct responsibility of its constituents in its conduct.

The chapters are anxious to take over some of the work that has been formerly done at national headquarters, such as passing on qualifications of applicants and collecting dues. The chapters feel the need for building their organizations up into powerful local organizations and strong representatives of the national association.

Association Building.

The decision to appoint a board of trustees to consider acquiring a national engineering building in Chicago was the first business transacted by this sixth annual convention of the American Association of Engineers, which now has over 17,000 members. The building program will be formulated by the Board of Trustees and formally approved later by the Board of Directors. It was announced that the City Hall Square Building in Chicago might be purchased.

The same Board of Trustees will also consider the proposition of providing group insurance for members of the association, in accordance with a resolution introduced by Garrison Babcock, a consulting telephone engineer of Chicago.

Salaries of Engineering Teachers.

Salaries of teachers in engineering colleges in the United States were recommended tentatively by A. N. Johnson, consulting highway engineer of the Portland Cement Association of Chicago, and Daniel L. Turner, chief engineer of the Transit Construction Commission of New York City, reporting for the committee on salaries of engineers in teaching service, of which Prof. C. J. Tilden of Yale University, is chairman. The dean of an engineering college is recommend for a salary of from $8,000 to $15,000 per annum, depending on the size of the college; professors, $5,000 to $12,000; associate professor, $4,000 to $9,000; assistant professor, $3,600 to $7,500; instructor, $3,000 to $4,000; assistant instructor, $1,800 to $2,400.

Unionism in the Profession.

Unionism in the engineering profession was strongly condemned in a resolution endorsing a statement issued by the Board of Directors of the association, reading in part as follows.: "We believe in organized representation for the correction of wrong, the advancement of the engineering profession, and service to the public, but are opposed to methods inconsistent with the dignity of the profession and which would lessen public confidence in engineers. The American Association of Engineers, recognizing the many fundamental differences between the principles and objectives of the trade union and an organization of professional men, expresses the opinion that an engineer can not subscribe to the tenets of both." The resolution recommended the expulsion from the association of engineers those who advocate strikes or similar methods of securing their ends.

Resolutions.

The association also decided to ask candidates for the presidency to declare themselves for or against the proposed national department of public works, for or against a national budget, for or against a constructive program of conservation of natural resources, and for or against reclamation of waste lands.

Another resolution declared that "adequate highway transportation is a prime requisite for the proper development of all sections of our country," and urged encouragement of worthy highway projects and the continuation of appropriations by congress as federal aid.

The immediate restriction of the exportation of such natural products as petroleum and its products, wood and wood-pulp, paper, etc., will be urged upon congress as a means of conserving the natural resources of the country.

"One of the most important means of stabilizing conditions and values lies in greater individual application and industry," read another resolution, and it was enthusiastically adopted, with a pledge that each member would direct his efforts toward the end aimed at by the resolution.

The scheme of Secretary of Agriculture Meredith for the utilization of timber reserves of Alaska for the manufacture of wood-pulp for paper was endorsed as a feasible method of reducing the shortage of print and other paper. The association pledged itself to aid in this project in every way possible.

The legislature of Delaware was urged to adopt the suffrage amendment to the federal constitution.

To establish the supremacy of the United States in airship development, a resolution was adopted urging congress to enact legislation authorizing federal development of aircraft on a large scale, or the construction of aircraft by subsidizing commercial organizations.

Officers Elected.

The following officers of the association were elected for the present year: President, L. K. Sherman, president of the U. S. Housing Corporation of Washington; Vice Presidents, H. O. Garman, chief engineer of the Public Service Commission of Indiana, Indianapolis, and A. B. McDaniel, principal engineer of the construction division of the army, Washington; Directors, Edmund T. Perkins, consulting drainage engineer of Chicago, Charles A. Finley, managing engineer of the water bureau of the city of Pittsburgh, W. C. Bolin, an engineer with the Baltimore & Ohio Railroad of Chicago, B. A.Bertenshaw, valuation engineer of the Big Four Railroad, Cincinnati; Prof. Frederic Bass of the University of Minnesota, Minneapolis, and R. W. Barnes, principal assistant engineer of the Southern Pacific Railroad, Portland, Ore. Retiring President F. H. Newell, head of the department of civil engineering in the University of Illinois becomes a member of the board of directors automatically. The following directors hold over another year: Raymond Burnham, consulting engineer of Chicago; E. F. Collins, civil engineer of St. Louis; P. E. Harroun, consulting engineer of San Francisco; A. A. Matthews, chief engineer of the St. Louis and Southwestern Railroad, and F. D. Richards, consulting engineer of Cleveland, O.

The 1921 convention will be held in Buffalo, N. Y.

HISTORY OF WARRENITE—BITULITHIC ROADS AND PAVEMENTS AND SOME NEW DISCOVERIES IN PAVEMENT CONSTRUCTION

By George C. Warren, President Warren Brothers Company, 142 Berkeley St., Boston, Mass., in Addressing Class in Highway Engineering at Valparaiso (Ind.) University, May 14, 1920.

Early in the year 1901 the, then entirely novel, construction which has developed into Warrenite-Bitulithic was first brought to the attention of your instructor, Professor Charles Carroll Brown, then editor of "Municipal Engineering" (now Municipal and County Engineering), by its inventor and the writer's brother, the late Frederick John Warren. It was then little more than a collection of embryonic thought in the inventor's mind, engendered by 15 years' practical experience in the refining of asphalt and other bituminous materials, and in the laying of asphalt pavements, and 2 years' constant laboratory work in development of the new idea.

Fundamental Idea.

Fundamentally, this idea was that better and more durable bituminous pavements than those in previous use could be produced by scientific grading of comparatively coarse grain mineral aggregate (either gravel or crushed stone) combined with high grade asphaltic materials. Briefly, the principle of the grading of the aggregate, which was in the inventor's mind from his first study of the matter, was to make the compressed aggregate as dense as possible and coating the particles of aggregate, preferably heated, with specially prepared high grade asphaltic cement, the result being true asphaltic concrete, practically as dense and voidless as solid stone. This density is produced by combining particles of aggregate, ranging from the largest to impalpable powder, in such proportions that each receding size of aggregate is sufficient in quantity to fill the voids between the coarser sizes. With some surprise it was discovered that uniform sized grains of any given size contain the same percentage of voids or air space, these voids being approximately 50 per cent. of the bulk of the compressed aggregate of such uniform size. In other words, a block or piece of stone broken into pieces of uniform size, produces a bulk double that of the solid rock. In crushing, therefore, a cubic yard of ledge rock is increased in volume to 2 cu. yds. of closely screened uniform sized product, each separate uniform size containing approximately 50 per cent. voids. This is true whether 2 in. or larger size, or as fine as one two-hundredth inch or even smaller, in which the individual voids are so small that they can not be seen by the eye.

The first problem which presented itself to the inventor was to devise means of determining the proportions of varying sized grains, which would reduce the voids to a minimum and apparatus to make tests accurately and equipment to produce the result practically in large quantities. In these early experiments the inventor was assisted by August F. Schutte, chemist, and Horace W. Ash, mechanical engineer, both of whom are still associated with Warren Brothers Company.

Void Testing Apparatus.

Schutte invented the truncated cone for testing voids and determining proportions, it being found that all prior means of testing voids were quite inaccurate and unreliable. For instance, the old method of attempting to fill the voids with water only found a portion of them as the water did not expel the air from the smallest voids, which constitute a very large proportion of the total voids. Another method of shaking the material in a cubical box was also inaccurate because the more the box was shaken the more the fine material would sift to the bottom of the container and force the coarser particles upward to the point of "overflowing" the box. With the truncated cone having a base say 6 in. in diameter and top opening, say, half that diameter when the coarse particles of aggregate are shaken down, they are so wedged together and between the sloping sides of the cone, that power from below can not force them up. The cones were first made of heavy sheet copper soldered at the bottom and sides, but the pressure produced by shaking the aggregate was such that it bulged the cone at bottom and sides. It was found necessary to make the cone of steel as heavy as ⅛ in. securely riveted at bottom and sides. With this apparatus and violent shaking until no more material can be gotten into the cone, and by using the correct proportions of all grades of aggregate from coarsest to finest the 50 per cent. voids in the uniform-sized aggregate can be reduced to about 10 per cent. or to density within 10 per cent. of that of solid ledge rock. The cubical contents of the cone is known and the weight of compressed aggregate compared with the weight (determined by specific gravity) of a solid block of stone of the same cubical content and quality as being used for the test determines the percentage of voids. The results vary with varying shapes and sizes of each quality of aggregate, consequently the "void test" must be made in the laboratory in advance of pavement construction, using in the test the identical quality and sizes of aggregate to be used in the practical construction. With the voids thus determined the next step is to determine the quantity of bitumen, which is necessary to:

(a) Fill all the voids and a slight surplus.

(b) Thoroughly coat all the particles of aggregate with the asphaltic cement.

By these methods and practices and scientific laboratory control we are able regularly and practically to accomplish (what no other form of monolithic bituminous pavement, even approximately, accomplishes) to wit, compression of approximately 4 in. in depth of commercial ingredients into a compressed depth of 2 in.

From this brief description of the scientific rudiments it will be seen that the result is a highly scientific, true asphaltic concrete, having practically the density of solid rock.

Time, on this occasion, will not permit a description of the many other processes and forms of apparatus for testing both the ingredients used and the completed pavement, also the improved detail methods of construction, all of which service is furnished by highly equipped laboratories, with large forces of employes, one of which laboratories is located in Cambridge, Mass., and another in Portland, Ore., at each of which in the working season, approximately 100 complete tests are made daily, including daily samples from all of the approximately 200 places where Warrenite-Bitulithic roads are being simultaneously constructed during the busy season. Rudi-

mentary laboratory apparatus is also maintained at each operating plant. This is part of the very important service which Warren Brothers Company gives in conjunction with the use of its patents.

Equipment Invention.

Having overcome the difficulties of laboratory determination of ingredients to be used, the next difficulty was to devise equipment to produce, practically, the desired results as determined by laboratory operation. For this Horace W. Ash devised two general types of plants, which are diametrically opposite in their methods of accomplishing the same result, to-wit:

1. *Stationary, semi-portable; Portable Road and Railroad plant types* in which the aggregate first passes through rotary heaters in approximately the desired proportion; then is separated into several sizes by a sectional rotary screen of sufficient length and diameter to provide perfect separation; each size is kept separate in a sectional bin; accurately weighed in a box resting on a multi-beam scale and delivered to a "twin-pug" mixer, in which the hot bitulithic (asphaltic) cement is added.

2. *Portable plant type* for which the several sizes of aggregate are accurately measured, *before heating*, into a batch of certain weight; delivered into a rotary drier, heated by oil-burner flame; the batch held together as a unit and delivered into a rotary mixer, where the hot bitulithic cement is added. This type of plant, in one unit, is permanently mounted on its own wheels and can be drawn by steam roller or horses. It is therefore available for use either alongside railroad or in a quarry or gravel pit, or alongside a road being paved and is, therefore, most flexible in its operation.

It will be noted that each of these plant types is based on accurate proportioning of the several sizes of mineral aggregate into batches of certain size and each batch held as a seperate unit until thoroughly mixed with carefully weighed bitulithic cement and deposited in truck for hauling to the street.

Two hundred and twenty of these plants have been constructed and are regularly used throughout the United States and Canada. For construction of these plants very complete and extensive plants have been developed in Cambridge, Mass., and Portland, Ore., having a combined annual capacity of about 45 plants.

Resulting Development.

In the fall of 1901, when the actual construction had been limited to experimental areas in the cities of Pawtucket, R. I.; New Bedford, Mass., and Cambridge, Mass., the inventor, Fred Warren, addressed the American Society of Municipal Improvements on the then novel construction. He was asked by the then president of the Board of Public Works of a prominent city, which has since laid over 1,000,000 sq. yds. of the pavement: "Don't you think you will know more about this construction after you have used it for five years?" The answer given was: "If we do not learn something and put it in practical use every day, I should say we will be a failure."

The result, including the public confidence which has been earned, is best shown by the following table of development of Warrenite-Bitulithic, which includes nearly every state and territory of the United States and province of Canada.

WARRENITE-BITULITHIC AREA LAID AND CONTRACTED FOR IN 20 YEARS

Year	Cities and Counties	Square Yards
1901	7	16,400
1902	33	400,831
1903	40	915,630
1904	45	1,041,724
1905	42	1,041,327
1906	57	1,508,095
1907	66	1,924,222
1908	62	1,676,433
1909	79	2,071,987
1910	102	3,047,276
1911	112	4,189,182
1912	180	4,830,601
1913	171	5,081,068
1914	149	4,204,943
1915	154	4,495,393
1916	177	5,519,765
1917	192	5,219,173
1918	165	4,799,783
1919	187	7,467,331
1920*	227	14,811,438
		74,262,602

Total equals 4,219 miles roadway, 30 ft. wide between curbs.

*Laid and under contract to May 1st.

Foundation.

Aside from improvements in the Warrenite-Bitulithic pavement surface, Warren Brothers Company has been progressive in the matter of foundation and has established the now quite generally accepted fact that tensile or beam strength is only one of the important considerations for a pavement base and that given a well-compacted, well-drained sub-base the factor of beam strength becomes less important than:

1. Resiliency.
2. Thorough uniting of surface to base.

These considerations have taken the specific forms of:

(a) Economic conservation of old macadam roads and old pavements and foundations of other types of pavement by regulating the grade and contour and surfacing them with the dense, stable, solid, standard Warrenite-Bitulithic surface. In cases where the old macadam is of insufficient depth, say 6 in. or more of solid road metal, it is reinforced by the addition of the required quantity of new stone spread and compressed over the old macadam.

(b) New compressed stone base.

(c) Dense bituminous concrete base.

During the past ten or more years these types of base have been practically used under such widely varying climatic and other conditions as to prove their economic utility beyond peradventure.

Gravel Aggregate.

Beginning in the city of Portland, Ore., ten years ago, clean, sound gravel has been used on the mineral aggregate of both Warrenite-Bitulithic surface and bituminous concrete base to such a general and vast extent as to prove it to be fully equal to the best crushed stone.

Such gravel has the advantage over crushed stone of greater toughness and on account of its shape and toughness much less liability to fracture and displacement under traffic when exposed at the surface.

The theoretical objection held at one time that the rounded particles of gravel would not become firmly held in the structure and liable to displacement is thoroughly exploded by ten years' practical experience under widely varying conditions.

Surface Improvements.

In the year 1910, Edwin C. Wallace, who has been associated with the speaker in paving organizations for more than 25 years, developed and patented the invention

that the different sizes of the mineral aggregate in the wearing surface of a bituminous street pavement, in addition to being properly proportioned should also be properly placed in their relation to each other, that is, with the coarser dense stable bituminous mixture at the bottom where the stability is most needed and the finer bituminous mixture near the surface, making the pavement densest at the top.

Patents granted him cover both an improved product and the method necessary to be used in making the product, which is a monolithic, bituminous concrete, pavement wearing surface, in which the coarse and finer mineral aggregate is so distributed throughout the mass that the product is a bituminous concrete structure, comprising "a rigid portion and a surface sealed to the elements."

This improved product is produced by first spreading upon the prepared foundation, a bituminous concrete mixture consisting of relatively coarse and finer sized particles of mineral aggregate, which have been previously thoroughly coated with bituminous cement, then immediately spreading thereupon, a relatively thin layer of a bituminous mixture, consisting of fine mineral aggregate and bituminous cement, and then compressing these two bituminous mixtures together by rolling, so that the latter fine mixture is forced into the interstices between the larger paricles of aggregate of the lower course. The compression by rolling being continued until the entire structure can be compacted no further and the result is a bituminous pavement wearing surface, the lower portion of which is composed of bituminous-coated large, medium and small sized particles of aggregate, so disposed as to impart stability and rigidity, and its upper surface composed of bituminous-coated fine particles of aggregate, thoroughly bonded and anchored into the lower portion by compression, thus producing "a compact and substantially integral mass, which is densest at the top." This construction protects the coarse aggregate from penetration of moisture, also from fracture and displacement of the coarse aggregate by a thin surfacing about ¼ in. of fine mixture, extremely rich in soft bitumen and, therefore, extremely waterproof and wear-resisting, at the same time maintaining the essential solidity and structural strength of the dense coarse aggregate wearing surface. Beginning with demonstration areas 10 years ago, this construction has come to be the universally accepted improved standard Warrenite-Bitulithic wearing surface, and has proved to have all the merit its inventor anticipated.

Asbestos-Bitulithic.

In the year 1916 Schutte applied for patent which was granted in 1918 for a pavement and method of laying it, using asbestos fibre combined with mineral aggregate, along certain scientifically determined lines.

Owing to difficulty in securing economic supply of asbestos under war and post-war conditions, the general introduction of this improved construction has been deferred, but sample demonstration areas have been laid during the past three years in several sections of the country, particularly under the rigorous climatic conditions of New England.

One commercial contract was executed in New Bedford, Mass., in the year 1919.

Enough work has been done and in use for a sufficient term to prove its practical utility. Of course the asbestos adds somewhat to the cost, but at normal prices for asbestos, this is fully compensated by its advantages.

The presence of the indestructible asbestos fibre adds toughness to and overcomes the brittleness of the asphaltic cement and wearing properties of the pavement structure, to which it imparts very remarkable and desirable qualities.

While the proportions of Bitulithic cement and varying sizes of aggregate employed in the Bitulithic surface are modified to meet the conditions imposed by the asbestos, none of the well established principles of the otherwise latest improved Bitulithic construction are in any way sacrificed or lost. The name given to the construction is "Asbestos-Bitulithic." It offers great promise for further meeting the requirements of modern traffic conditions.

Double Re-Flushcoating.

In every type of pavement the time comes when its surface becomes dry and roughened under traffic. In the case of bituminous pavements on the theory of "A stitch in time saves nine," a double re-flushcoating method, devised and patented by Wallace, affords a most economic method of renewing to its original vitality the old partially deteriorated surface.

Briefly stated, the process consists of:

1. Thoroughly cleaning the old surface.
2. Repairing holes and depressions, if any.
3. Painting the surface while clean and dry in warm weather with cold asphaltic paint, made of Bitulithic cement, liquefied by light solvent, called "Liquid Re-Flushcoating Bitumen," which is allowed to remain without further application for a few hours and until the liquid asphalt has well penetrated into the old surface and the volatile solvent has evaporated.
4. Give the surface a second painting of melted hot "Hard Re-Flushcoating Bitumen" of the proper consistency.
5. While the second coating of bitumen is still hot, spread and roll sand or crusher screenings.

The work requires only about a total of ¼ gal. per sq. yd. of the two grades of Re-Flushcoating Bitumen, which are supplied ready for use at per gallon prices, including license to use the patents and Warren Brothers Company service charges.

Other Improvements.

Several other important improvements are now in process of demonstration but, pursuant to the policy of Warren Brothers Company, nothing is said publicly of its improvements until they have been sufficiently tried in practical use to demonstrate their economic utility.

WATER POWER AND CONSERVATION

By H. de B. Parsons, Consulting Engineer, 22 William St. New York, N. Y.

In the past we have been lavish in the use and consumption of the many natural resources with which the United States was wonderfully endowed by nature and have given little heed to future requirements. Now that the nation's resources are becoming scarcer, we are awakening to their value; and appeals arise sporadically for some system in their use, for efficiency to restrict

needless waste, and for conservation which will protect the requirements of those to come after us.

Waste of Wood as an Example.

We certainly have not shown foresight in the use of wood. Trees were cut many feet above the ground, because it was cheaper to stand on the snow in winter, when the cutting was accomplished. The stumps were left to rot, although they contained many millions of board-feet.

The Forest Service of the U. S. Department of Agriculture reports that the total cut from the forests of the United States is about 21,800,000,000 cu. ft. per annum, while the total yearly growth probably does not exceed 8,000,000,000 cu. ft. Thus the estimated total cut for all purposes is more than 2½ times the growth.

Southern pine is rapidly disappearing and it is estimated that in 15 or 20 years the present production will be cut out and that the mills will have to seek small areas of virgin growth and areas of second growth. Again white pine, formerly extensively used in the arts and in construction, is so extremely scarce that it is no longer a factor in the lumber market.

At present many paper mills are operating in territory completely stripped of timber and the railways are required to bring pulp to them from other mills located far away, many even outside of our borders. In the use of paper we have been, and are still, foolishly wasteful, and yet we complain at the ever increasing costs and prices. Are not some of these increases due to persistent lack of policy and foresight? Many think so. The extended use of iron, steel, brick and cement came too late to save the wood, and brick is now so expensive as to prohibit its use for many purposes.

We never have had any nation-wide system for reforestation, although the benefits have been studied, taught and preached for years. To replace wood, it is possible that the future will cultivate quick growing trees and grind the timber into pulp, which will be pressed into various commercial shapes.

Diminishing Coal Supplies.

It is quite apparent that the nation's coal supplies should be conserved by the intelligent use of its water resources. The author made a long and exhaustive search through the best records on file, including statistics published by the U. S. Geological Survey, and the figures obtained show that the available supply in the United States is about as below:

Anthracite and Semi-Anthracite—19,000,000,000 tons.
Bituminous and Lignites—3,550,000,000,000 tons.

Trade reports show that the yearly coal production is about:

Anthracite and Semi-Anthracite—90,000,000 tons.
Bituminous and Lignites—550,000,000 tons.

At these rates, assuming that there will be no increase in production, the present available supplies would last about 200 years for the anthracites and 6,450 years for the bituminous.

Crude Oil or Petroleum.

In a similar manner records show that the amount of crude oil or petroleum in the ground in the United States is about 7,000,000,000 barrels (of 42 U. S. gallons), and that the yearly production is at the rate of about 375,700,000 barrels. According to these figures the available supply would last for only 18 years. The amount of petroleum in the ground in Mexico is unknown, but Dr. David White, chief geologist of the U. S. Geological Survey, has expressed the fear that Mexico had less oil under ground in 1919 than the United States. The yearly production from the Mexican fields is about 300,000,000 barrels, and if the available supply is taken at the same figures as for the United States, namely 7,000,000,000 barrels, that country would be exhausted in about 23 years.

There are large oil fields in Canada, but their extent is not known at this writing. As the American and Mexican wells show territory exhaustion the production from Canada should rapidly increase from the present production figure of approximately 500,000 barrels per year.

In Venezuela and adjacent countries, there is a vast resource of crude petroleum. This supply, as well as other fields yet to be discovered, will help sustain the demand for oil and increase the length of time before complete exhaustion will be reached, but they are outside of our boundaries and we will have to share their value with others.

There is a promising outlook in the oil bearing shales to be found in different parts of this country, from which fuel and possibly lubricating and other oils may be obtained. This industry has not yet been developed and it is hard to predict what the result may be.

There is danger in using the above figures through the possible and probable inaccuracy of the available supplies. This is especially true of the coal fields. There is no doubt more coal in the ground than reported, as many owners do not carry out prospecting developments beyond the limits needed properly to finance their companies. It is true, however, that the better grades of anthracite will be exhausted in much less than the 200-year limit mentioned above, and that nearly all the hard coal near the surface will be removed in the next three generations, leaving only the deeper strata for future mining operations. This also is true for the bituminous and lignite-grades, so that in a few centuries all our coal may have to be taken from depths exceeding 3,000 ft. These changes will seriously add to the cost of labor for production and raise the prices of all kinds of coal fuel.

The high cost of labor, by increasing the cost of production, is adding a burden which is seen in every walk of life. While labor should be well paid, the men have little or no financial responsibility, and each should see that every one does a "full day's work" in return for his full wage.

Value of Hydro-Electric Power Becoming More Apparent.

As time progresses the value of hydro-electric power will become more and more apparent, and, in fact, will be needed to meet the ever increasing demands for power and production.

The present need of production has brought up the question of lack of power, and in this connection we look to the water powers as a never failing source of cheap supply. In the July, 1919, issue of "Municipal and County Engineering," the author contributed an article on this subject and pointed out that great economies could be accomplished by a proper and systematic policy

for the development of our hydraulic resources. There is an erroneous impression in the public mind that any policy for water-power development would be a step to benefit private enterprise for personal gain. This is a narrow minded view and fails to grasp the broader aspect that the public is vitally interested. A policy, which will increase our national wealth and welfare, and which will be advantageous to the nation as a whole, must benefit each and every individual, either directly or indirectly.

It has been stated * that the water powers of the United States, as compared to steam powers, are:

Water powers, total potential, with storage, 200,000,000 h. p.

Water powers, not developed, without storage, 50,000,000 h. p.

Water power, developed and in use, 6,000,000 h. p.

Compared to steam power, developed, 40,000,000 h. p.

Water Storage.

Storage means the regulation of the flow of the rivers, by storing the flood waters for use in dry months, as, unfortunately, the flow is not even and continuous throughout the year. On some water sheds the variation is very wide. The primary, or all-year-round power, is limited to the minimum flow in the dry season. The full maximum flow can not be utilized, as it lasts but a short period of the year, and it does not pay to install expensive machinery to transform this flood flow into power on account of its short seasonal use.

The World's Demand for Power.

The total of the world's demand for power is extremely hard to estimate. It has been stated that the present power demand of the world is about 120,000,000 horse power† and that it is divided as follows:

For factories, electric lighting and street railways, 62½ per cent.

For railways, 20 per cent.

For shipping, 17½ per cent.

The total potential water-power of the United States exceeds this figure for the world's demand, or, in other words, the water-power of the United States could be developed to supply more than the world's demand without the use of coal, oil or fuel of any kind. In fact, the demand for power at the present time in the United States is about 46,000,000 h. p., including both steam and hydraulic installations, while there is available, but not developed, some 50,000,000 h. p., even without recourse to storage.

All Water Falls Are Not Valuable For Hydro-Electric Development.

When delivering a series of lectures at Rensselaer Polytechnic Institute in 1915, the author told the students that *all* water falls were not valuable for hydro-electric development purposes, because interest on the cost of development formed too large a proportion of the operating expenses to make some investments profitable. In brief, a development would not pay when the product of flow in cubic feet per second by the head in feet was less than 16,000. While this is not a fixed ratio, because natural advantages in some locations makes the cost of development per kilowatt, or per horse power, much less than at other places, it can be used as a close guide in forming first hand opinions. As was stated in a previous article, every project for hydraulic power development should be carefully reviewed by an engineer whose experience has made him competent to pass on the questions involved.

The following statement will serve to illustrate how the ratio just mentioned was determined:

Assuming Cost of Hydraulic Development.

Dam, head race, tail race, screens and power house, etc.	at $ 93 per kw.
Turbines, draft tubes, etc.	at 7 per kw.
Electric generating machinery and equipment	at 20 per kw.
Transmission line, transformers, etc.	at 15 per kw.
Total cost	at $135 per kw.

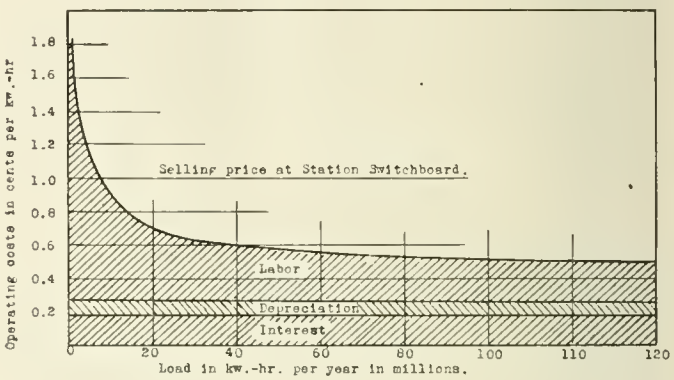

Fig. 1. Avg: cost per kw.-hr.
Note:- Cost of land is not included.

FIG. 1—CHART OF HYDRO-ELECTRIC AVERAGE OPERATING COST PER KW. HR., COST OF LAND NOT INCLUDED.

The operating costs of generating stations per kw-hour, delivered from the station switch board, on a 50 per cent. load factor basis, would be (say):

For labor, up-keep, taxes	$0.00312
For interest at 6 per cent. on $135=$8.10, which for 4,380 hours in year at 50 per cent l. f., is.	0.00185
For depreciation—	
Taken at 2 per cent. on $93=$1.86	
Taken at 5 per cent. on 27= 1.35	
Taken at 3 per cent. on 15= .45	
Total	$3.66
—which, for 4,380 hours in year at 50 per cent. l. f., is	0.00083
Total operating cost	$0.0058

The current thus generated could be sold for about $0.01 per kw-hour, as an average of primary and secondary power, at the station switch board.

The operating costs are graphically shown in Fig. 1, and the curve rises sharply as the station load falls below 25,000,000 kw-hrs. per year. On this assumption, a development, which has a yearly load of 7,500,000 kw-hrs. or less, would not pay on an average selling price of 1 ct. per kw-hr. Such a load would require a plant having a capacity of 1,700 kw. (7,500,000 divided by 4,380).

Taking combined efficiency of turbines, generators,

(*Continued on page 248*)

*"Power: "Its Significance and Needs," Smithsonian Institution, U. S. National Museum, Bulletin 102, Part 5.

†"Report on the Water Power Resources of India," by J. W. Meaves, M. Inst. C. E. Calcutta, 1919.

BEFORE USING TARVIA
Photograph shows wretched condition of Fourth Avenue, Milwaukee, Wis., before it was salvaged with "Tarvia-X."

AFTER USING TARVIA
The same street, showing how the "Tarvia-X" resurfacing has made it smooth, mudless, dustless and traffic-proof.

To Get Good Roads—Cheaply—Quickly—Save the Roads You Have!

MILES and miles of good gravel and macadam roads throughout the country can be restored to meet modern traffic requirements. The way to do this is to utilize the existing road as a foundation for a traffic-proof Tarvia top. And where crushed stone or slag is available, the community so favored not only can save its roads but *save* considerably *money* in the bargain.

Many progressive communities recognize this fact and are carrying out an extended *road salvage program* rather than build new roads at present exorbitant prices.

For example, the City of Milwaukee has in this way transformed 1,700,000 square yards of water-bound macadam into splendid modern streets to the complete satisfaction of both the city authorities and the traveling public.

Whether you require a good binder for new construction, a dust-preventive, a patching or maintenance material, Tarvia, in its various grades, provides an economical and satisfactory solution.

Tarvia Roads are durable, dustless and mudless. They are also waterproof and frost-proof and require a minimum of upkeep expense.

Illustrated Booklet, telling about the various Tarvia treatments, free on request.

Tarvia

Preserves Roads~Prevents Dust

Special Service Department

This company has a corps of trained engineers and chemists who have given years of study to modern road problems. The advice of these men may be had for the asking by any one interested. If you will write to the nearest office regarding road problems and conditions in your vicinity, the matter will be given prompt attention.

New York, Cincinnati, Minneapolis, Atlanta, Lebanon, Chicago, Pittsburgh, Dallas, Duluth, Youngstown, Philadelphia, Detroit, Nashville, Salt Lake City, Milwaukee

The Barrett Company

Toledo, Columbus, Richmond, Latrobe, Bethlehem, Boston, New Orleans, Syracuse, Bangor, Elizabeth, St. Louis, Birmingham, Seattle, Washington, Buffalo, Cleveland, Kansas City, Peoria, Johnstown, Baltimore

THE BARRETT COMPANY, Limited, Montreal, Toronto, Winnipeg, Vancouver, St. John, N.B., Halifax, N.S., Sydney, N.S.

(Continued from page 246)

switchboard and transformers at 70 per cent., 1 kw.= 0.106 × cu. ft. sec. × head.

Therefore, a paying development should show:

0.106 × cu. ft. sec. × head, greater than 1,700

or cu. ft. sec. × head, greater than 16,000

The first cost of development of a water-power is very variable. For instance, installations of 7,500 kw. and larger, might possibly be (on a pre-war basis):

	Max.	Min.	Appr. Avg.
For hydraulic works	450	40	90
For waterwheel machinery	10	5	7
For electric machinery	150	8	20

For transmission lines—depending on length.

Plants with high heads and small flow in general cost less than those with low heads and large flows.

The operating costs of American hydro-electric stations also are valuable between wide limits, depending on location and power-factor demand. Thus, the costs for the larger stations will run from, say $11.50 to $43 per kw. per year. The selling price naturally depends on the cost. Consumers will pay for *"reliable"* power, that is power which can be relied on throughout the full year. Reliability is worth money and commands high rates. Cheap power, if unreliable, is not always economical.

As water-power is not constant, since the flow of the river is low in the dry season, only a portion can be sold as primary power, and the balance must be classed as secondary and demands a lower selling price. The loss of interest on the necessary machinery while idle is a factor which must be considered, and is a large factor on rivers where the flow has a wide range throughout the year.

Auxiliary Steam Plants.

In order to make up loss of power when water is low auxiliary steam-driven plants are kept in reserve. As coal and fuel oil are becoming scarcer and higher in cost the present tendency is to locate such steam plants at or near the mines where coal of cheap grades can be supplied. The electric generating stations, both steam and hydraulic, can be connected by a system of transmission lines running across country, and the current fed out to users as desired. It is mechanically feasible to meter the current supplied from the generating stations into the distributing system and arrange credits for each station. Such a plan would secure economies in many ways and relieve the railways from carrying coal long distances, which traffic so frequently blocks passenger and fast freight trains.

RECONSTRUCTION OF 20-YEAR-OLD ASPHALTIC PAVEMENTS IN OKLAHOMA CITY

Oklahoma City, Okla., is starting on a program of reconstruction of streets which were paved with sheet asphalt, over a concrete base, about 20 years ago.

Under the specifications for this re-construction work, the old concrete base is brought to a true contour by building up the deeper depressions with cement concrete, and the shallow depressions with close binder. A 10-ft. gutter of grout filled 3-in. vertical fibre brick set in a mortar cushion, extends from the curb on the streets which are 40 ft. or more in width, in the business sectios where cars are parked for a long period. After the brick gutters have become set a 2-in. binder course using a lean asphaltic concrete mixture is laid and rolled. On this binder course is laid 2 ins. of asphaltic concrete carrying a high percentage of fine material, especially 200 mesh, with the balance of the mineral aggregate well proportioned up to ½-in. material.

The first rolling of this wearing surface of Texaco asphalt is a cross rolling instead of longitudinal, using a 5-ton roller, which on account of brick gutters, can cover the entire asphalt surface with the large wheel of the roller. Immediately following the cross rolling a longitudinal roll is given the wearing surface, using an 8-ton tandem roller. The surface completed under this method up to date shows a minimum of waves.

Another feature which will tend to preserve a uniform surface, is the prevention of asphalt rakers from walking or standing on the hot mixture after it is handled by the shovelers and prior to rolling. This eliminates an excess of mixture in the spots which have been walked upon and receive a certain amount of compression before the roller is applied.

In this section of the country most cities demand that automobiles be parked along the curb at an angle of 45 degrees, and the gutter mentioned above should take care of this class of traffic during the summer months.

ASPHALT ROADS IN NEW JERSEY

New Jersey is known as the "Garden State of the East," and her counties are prolific in their supply of foodstuffs for the great cities in that part of the country. New York City and Philadelphia receive abundant quantities of fruits and vegetables from the fertile soil of Jersey, and an idea of the regard the metropolis holds for her supply of food coming from her neighbor state may be gained from the anxiety which exists in the city when the ferries and other means of transportation are tied up and it is impossible to get the eatables.

Burlington County, New Jersey, is one of the largest and most productive agricultural areas in the state, or in the East. Various kinds of fruits and vegetables are grown there, and consequently the means for transporting the county's foodstuffs has long been one of the chief problems of the residents. After finding that the railroads are unable to accommodate rapidly and conveniently the growing demand for its food products, the county has begun an extensive road building program.

Last season more than 10 miles of sheet asphalt were laid in Burlington County, and during the present season 20 miles of sheet asphalt will be constructed. James Logan, county engineer, is in direct charge of the work, which is being let to contractors in the usual manner.

One of the features of the work in Burlington County is the fact that the farming population is virtually unanimous in its desire for modern, high-class roads. The value and efficacy of durable highways has been proved to the farmers. A stretch of sheet asphalt extending from Mount Holly easterly towards the state capital of Trenton, is an example of these roads. This road was built in 1917 on an old macadam base, and has withstood without any maintenance all the banging, weighty traffic going to Trenton and other cities.

WATER WORKS SECTION

CENTRIFUGAL PUMPS FOR 900-FT. HEAD

By Farley Gannett and Jacob L. Crane, Jr., of Gannett, Seelye & Fleming, Inc., Consulting Engineers, Harrisburg, Pa.

The municipal water works at Shenandoah, Pa., is completing an installation of two 2-million-gallon per day centrifugal pumps, electric motor driven, to pump against a total head of 800 to 900 ft. The pumps, which are only three-stage for the head stated, together with certain details of installation, are of unusual interest. Incidentally, but by no means least important, pumping costs are to be reduced by $15,000 per year, a reduction of nearly 40 per cent.

Water Pumped Over Locust Mountain

Shenandoah is a community of about 35,000 population, situated in the heart of the famous lower anthracite coal region of Pennsylvania. The valley in which Shenandoah is located is so full of coal operations that it is impossible to secure water either from the surface or from below ground. It therefore became necessary to secure water in the adjoining valley, separated from Shenandoah by Locust Mountain about 800 ft. high. The water works plant uses the surface flow from several small mountain streams impounded in a small reservoir, and at present, the water is forced by stream pumps over Locust Mountain to the distribution reservoir and thence to the city.

Reasons for Changing from Steam to Electric Power

These steam pumps, as well as the boilers and pumping station, now 20 years old, are nearing the end of their useful life. Still more important, the advancing costs of coal, and of the two-mile haul from railroad to pumping station, and of firemen's wages, have so increased the cost of steam pumping as to cause a serious deficit in each year's water works finances. The high voltage transmission line of the Harwood Electric Company has been built since the steam pumps were installed; the electric rates, which are not expected to advance, show a large saving over steam power; the electric driven centrifugal pumps cost less than new steam pumps, require less space, are more easily and satisfactorily operated and allow the best advantage for taking power from the electric lines. It was therefore decided to put in electric-motor-driven centrifugal pumps.

Contracts and Guarantees

Contracts were drawn and bids taken on two centrifugal pumps and motors for 2 m. g. d. each against a maximum head of 900 ft. These contracts were drawn to admit bidding by almost any make of pump, but bonds and payment reservations require full performance of the terms of contract, including a required minimum efficiency overall, "wire to water." Seven bids were received and the contracts were awarded to John R. Proctor, New York for two American Well Works pumps and two 500 H. P. General Electric Company motors, at a total for all, installed, of $13,380, and a guaranteed overall efficiency of 68 per cent. Other items of the contract were: Building, about $5,000; piping, about $5,400; electrical equipment (transformers, sub-station, switchboard, instruments, etc.) $12,155.

The American Well Work pumps are three stage built for 300 ft. per stage. The shells are of cast steel, the wearing rings of bronze, shaft sleeves of bronze, shafts of forged steel and the impellers and diffusion vanes of "U. S. Government Bronze." The pumps are completed and are now being tested at the pump works. The guaranteed efficiency is noteworthy, 68 per cent. overall, "wire to water."

Protecting Old Steel Main Against Water Hammer

The discharge will be into a 12 in. steel force main 12,000 ft. long and 26 years old. The danger of blowing out this line when the pumps close down suddenly and the water slams against the check valves at the pumps, creating a water hammer which might be disastrous, in view of the length of line and high head, seemed so great that special provision was made to prevent it. The force main is divided into four sections by three check valves and just above each check valve and also at the pumps an automatic blow-off valve is placed. This serves to divide up the length of line and also the pressure, and allows the pressure to be relieved at each of the division points. This scheme is calculated to relieve the water hammer successfully.

The installation will be completed this summer, when rigid operation tests will be made and the results, which should be interesting will be reported to the profession through Municipal and County Engineering.

WATER MAIN CLEANING IN ST. LOUIS, MO.

By Edward E. Wall, Water Commissioner, 312 City Hall, St. Louis, Mo.

The St. Louis Water Department, realizing the advantage of clean mains for clean water, has probably had more miles of water pipe cleaned than any other city. For a long time after the initial clarification of the water in 1904 local disturbances of the normal flow in the mains would stir up the deposits in low points and cause numerous complaints from consumers in the affected district because of the turbid water flowing from their faucets. To get rid of this sediment accumulated throughout the 70 years of pumping the untreated and unclarified muddy river water through the mains, a systematic and regular practice of blowing off all low points and dead ends in the distribution system was inaugurated. By this means and also through the draughts on the mains during fires,

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and on rarer occasions of broken mains, a great deal of sediment was flushed out.

Yet there remained enough to cause serious inconvenience here and there whenever there was any considerable change in the velocity or direction of the usual current flowing through the mains.

These occurrences became less and less frequent each year, but were sufficiently annoying to give color to the suspicion that the water carrying in suspension a portion of these old deposits, was unhealthful and might possibly contain pathogenic germs.

First Mains Cleaned in 1908

In the autumn of 1908 some work at cleaning mains was done as a matter of demonstration. About 1,000 ft. of 10-in. main in Broadway and a shorter length of 6-in. pipe in the water works grounds at Bissell's Point were cleaned at a cost of $569.08. No measurements of the carrying capacities of these mains before and after cleaning were made, but the amount of incrusted and deposited material removed was found surprisingly large, and a recommendation was made that the process be continued until all the older pipe lines were cleaned.

However, nothing more was done in this direction until 1912, when about 4½ miles of 15-in. and 20-in. mains over 30 years old were cleaned at a cost of $5,517.09.

These lines were cleaned primarily to increase their capacity, so that the territory supplied through them could enjoy better pressures and a more uniform supply.

While no measurements were made of the increased capacity and no record kept of the amount of sediment and incrustation removed, yet the improvement in the service to the district supplied was very marked and encouraged the department to continue the work in 1913, when 2.62 miles of 6, 15 and 20-in. were cleaned.

Just prior to the completion of the Chain of Rocks filters the question of cleaning the mains to remove the deposits of sediment before a filtered and sterilized water was pumped into them, was again agitated, but because of the great mileage of mains which had been in service for 25 or more years, only a small fraction of which would be cleaned before the completion of the filter plant, all idea of a general clean-up was abandoned.

Plan Made in 1917 to Clean 50 Miles of Mains

On account of the great amount of construction work done from 1913 to 1917, during which time over $4,000,000 was spent in enlarging and improving the water works, the work of cleaning mains was suspended. In 1917 a comprehensive program was laid out for cleaning some 50 miles of the oldest distribution mains in the city and $50,000 was appropriated for that purpose.

This contract was completed in August, 1918. Careful observations, tests and measurements made of the incrustation removed from the mains showed the following results:

Size of main inches	Length cleaned feet	Weight of average incrustation per foot in pounds	Tons removed (dry)
6	58,061	0.846	24.56
8	15,691	1.784	14.00
10	1,180	2.040	1.20
12	115,025	3.303	189.95
15	7,205	3.970	14.37
20	70,125	6.472	226.92
Total	267,287 ft, or 50.6 miles		471.00

The incrustation as scraped from the inside of the pipe was found in its wet state to weigh 84.7 lbs. per cubic foot, but when dried only 68.5 lbs., losing almost 20 per cent. In cases where the main was not carrying any-

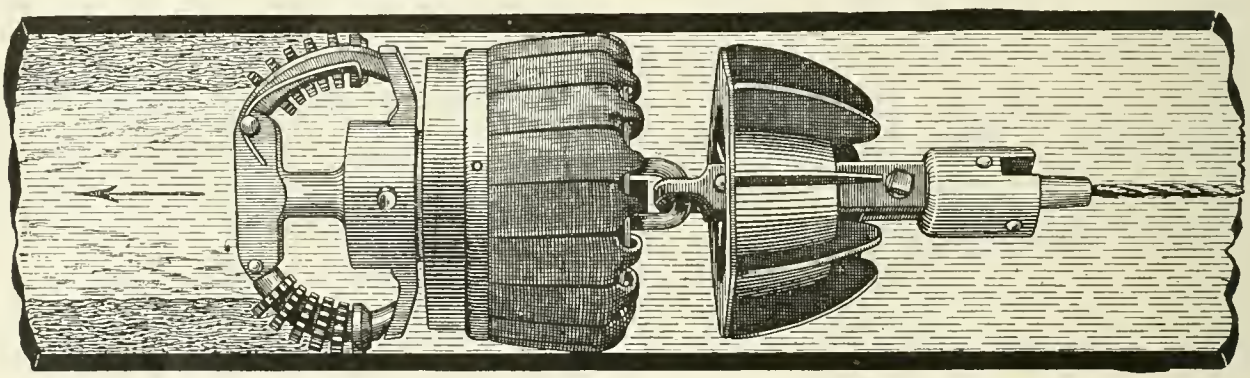


FIG. 1—VIEW OF MECHANICAL CLEANER FOR STRAIGHT WATER MAINS.

where near its full capacity heavy deposits of silt were found at the low points. This was also true of all dead ends and pipe lines where the normal currents ran with a low velocity.

Variety of Objects Removed from Mains

The variety of mobile things found in the pipe during the process of cleaning was most astonishing. A stick of timber, once 4 by 4 ins. and 6 ft. long, now with edges and ends rounded and worn away; oak wedges and hand spikes used in pipe-laying, horseshoes, paving brick abraded by traveling with the current until they resembled the granite pebbles under a glacier, broken stone, strands of rope, the remains of a workman's overalls, and even a steel drill bar 6 ft. long were among the specimens removed. With all the care usually taken in laying water pipe to see that each length is clean before putting it in the ditch, and then carefully blocking the open end at night, it is difficult to understand how some of these things could possibly have found their way into the pipe.

The presence of these moving obstructions in the pipe explains why it is often impossible to make a dry shut-off, as well as why stop-valves are found to be damaged and leaking.

Procedure in Cleaning Mains

In cleaning the smaller mains up to 10 ins. in diameter

the cleaning machine is dragged through by a cable. First a light line is carried through the pipe by a float, then the cable is attached to the line and pulled through by a windlass.

In cleaning the larger mains the machine is forced through by the water pressure behind it, the main being re-connected after the machine is inserted, and the water turned on with full pressure behind the machine. Space is allowed for a portion of the flow to pass through and around the machine so that the silt and incrustation loosened may be washed out of the way of the machine.

The Cleaning Machines

The ordinary cleaning machine consists of sections flexibly connected, each section having a number of tempered spring steel cutting and scraping blades securely fastened to a common center.

The cutting edges of these blades form a circle somewhat larger than the inside diameter of the pipe to be cleaned, so that when it is inserted in the pipe the tension on the blades is sufficient to cut and scrape away all incrustation.

A turbine type of cleaner has been designed for use in cleaning pipe where the interior deposit is very hard. This consists of a cleaning head attached to the motor of a water turbine. The cutters are pressed out against the incrustation by centrifugal action due to the rapid revolution; the stator is fitted with one of two pistons, which make a practically water-tight joint in the pipe line so that all the water flowing through the pipe must pass through and operate the turbine.

To the rear of the stator is attached a fitting which tends to prevent the rotation in the pipe of that part of the turbine which should not revolve. The entire machine is held back by a cable and specially designed windlass, as otherwise the pressure of the water would cause an uneven advance of the machine, which would jam the cleaning head into the incrustation and prevent its operation. Figs. 1 and 2 show the turbine cleaner in operation.

Rate of Progress in Cleaning

Where mains are cleaned by dragging the machine through, the length of pipe cleaned at one operation ranges from 1,000 to 2,000 ft. Where the machine is driven by water pressure as great a length of pipe as 6,400 ft. has been cleaned between openings.

The average speed of the machine when pulled by cable was 16 ft. per minute and when driven by hydraulic pressure was about 200 ft. per minute.

All service pipes connected to the main are shut off during cleaning to prevent their being filled up and clogged with silt and finely divided incrustants, yet it frequently happens that the consumer is unable to get water after the main has been cleaned until his service connection has been blown out by a plumber.

Contract Let in 1918 or Cleaning 100 Miles of Main

An appropriation of $115,000 was made in 1918 and a contract let in December of that year for cleaning about 100 miles of mains, ranging in size from 6-in. to 20-in. Up to Feb. 1, 1920, a total of 83.3 miles have been cleaned under this contract, from which an estimated quantity of 854.5 tons of incrustants have been removed.

Under the terms of the specifications the contractor guarantees that the pipe after cleaning shall have a carrying capacity equal to 95 per cent. of new pipe. Random tests made before and after cleaning show that with two exceptions in all cases where the machine was driven through the main by water pressure the capacity of the cleaned pipe was equal to or greater than that guaranteed. In the one case noted the pipe was re-cleaned, after which the test showed the required capacity.

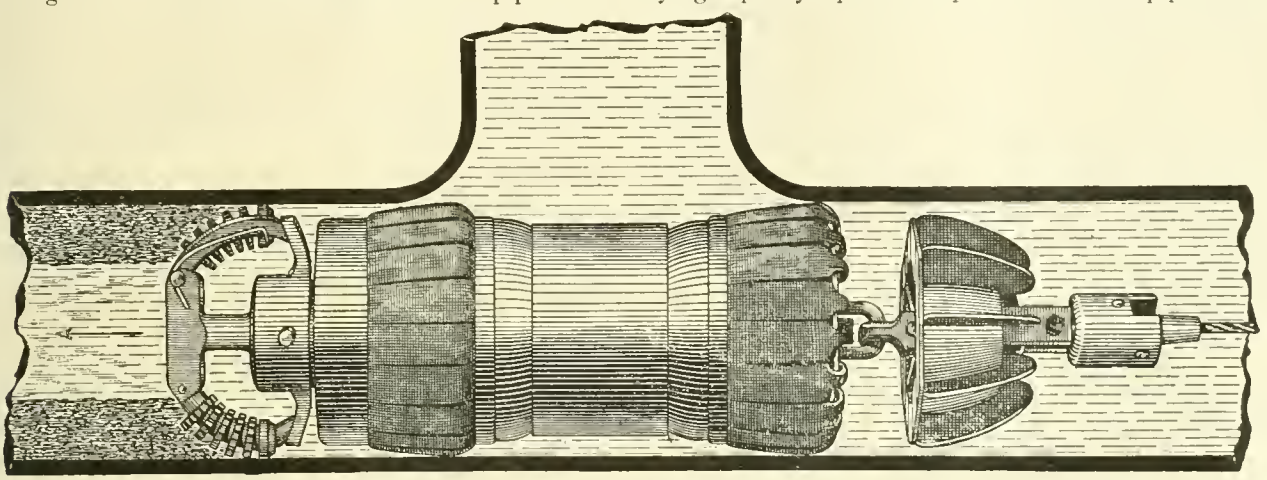


FIG. 2—VIEW OF MECHANICAL CLEANER FOR BRANCHED WATER MAINS.

In testing some 6-in. lines immediately after cleaning they were found to have the capacity specified in the contract, viz., 95 per cent. of that of new pipe. For example a 6-in. main on Pine street beore cleaning showed that its capacity was only 33 per cent. of new pipe, while after cleaning its capacity was 96 per cent.

Degree of Permanency of Results

However, several other lines where the efficiency of the cleaning was just as marked have deteriorated very rapidly to about 65 per cent. of new pipe, which value they seem to hold.

In this connection examinations of sections of 6-in. pipe after cleaning show the coating abraded and rust streaks in the process of forming. This neutralizes to some extent the good accomplished by cleaning.

Tests made on 6-in. pipe from 3 to 11 months after cleaning show a falling off in carrying capacity which can only be attributed to the rapid accumulation of rust about these abrasions. Apparently it is going to require a rather close adaptation of the strength of the spring steel scrapers to the quantity and hardness of the in-

crustant in order to have a machine which will insure a thorough cleaning and yet not injure the interior coating of the pipe.

It is intended this year to clean at least one pump main, probably the one leading from the Bissell's Point pumping station direct to Compton Hill reservoir, a distance of 4.36 miles, two-thirds of which is 36-in. in diameter, the rest being 30 ins. This pipe was laid in 1868-70 and was the first pump main connecting the new pumping station with the new reservoir.

Should tests after cleaning show a decrease in friction loss sufficiently large to justify the expense, about 7 miles more of the 30 and 36-in. pump mains will be cleaned.

Conclusion

When it is considered that the tests show an increase in carrying capacity ranging from 85 to 92 per cent. after cleaning, there can be no doubt that water main cleaning should be seriously considered by all cities whose mains have been in service 20 or more years. Wherever there occurs an inadequate supply or decreased pressures in districts where the mains were laid years ago it is certain that cleaning will afford relief. There have been several instances in St. Louis where the service has been so materially improved after the main has been cleaned that plans for replacing the existing line with new and larger pipe have been dropped.

The best evidence of the beneficial effects of water main cleaning in St. Louis lies in the fact that this work is being continued from year to year.

AMOUNT OF LEAKAGE IN SMALL WATER WORKS SYSTEMS

By Lawrence W. Cox, Consulting Civil Engineer, 1102 York St., Des Moines, Ia.

In Iowa, as well as in many other states, a large portion of the small cities and towns find it practically out of the question to secure adequate water supplies. In addition to inadequacy of supply, a great number of these municipalities secure such water as they do have, from considerable depths, a head of 200 ft. to 400 ft. below ground level being quite common. The capacity of these wells is often as low as 15 G.P.M. Water in such small quantities and pumped from such depths is expensive at best, due not only to the power consumed but also to the relatively high first cost, interest, depreciation and maintenance costs of the well and pumping equipment. For these reasons it is imperative that leakage in the mains be reduced to the lowest practical limits.

Leakage From New Mains

Among the laymen and even some practical water works construction men there seems to be the opinion that water mains when first constructed, can be absolutely water-tight. It is not uncommon to hear a water works superintendent say that a certain system of new mains has no leaks. Upon questioning it is usually found that the statement is based on the fact that after backfilling the pipe and turning on the water, no leaks forced water to the suface. Several tests under such circumstances have shown actual leakage amounting to 1,000 or more gals. per mile of pipe per 24 hours. No leakage is an ideal condition that is seldom if ever met with in actual practice. The writer has tested but one such main. It was scarcely a half mile long and was constructed under his supervision under almost ideal conditions. Nevertheless there is a limit to the necessary amount of leakage in new systems, where care is used in the construction work.

The water mains in town of 1,000 population and less usually consist of a small amount of 8-in. cast iron pipe, some 6-in. cast iron pipe and considerable 4-in. cast iron pipe, all made up with lead joints. Sometimes a small amount of 1½-in. and 2-in. galvanized iron screw joint pipe is also used. The writer has made numerous tests of these lines but finds no good reason for believing that one of these sizes of pipe gives on an average a greater rate of leakage than another. Therefore in his specifications he makes no distinction as to the allowable rate of leakage in the various sizes of pipe.

Results of Leakage Tests

Below are a few results of definite leakage tests. These tests were, with but one exception, made before services were connected up, and in this one case services were all shut off at the curb line. The rates of leakage are in terms of gals. per 24 hours per mile of pipe. The pressure given in each case is the approximate average pressure for the entire system, in pounds per sq. in. In each case the trenches had been backfilled from one week to several weeks or months.

The test data follow:

Locality	Pressure and other conditions	Leakage per 24 hours per mile of pipe
Clara City, Minn.—		
	Pressure 50 lbs., by elevated tank test...	660 gals.
	Pressure 115 lbs., by hand pump test....	750 gals.
	After repairing one leak, pressure 115 lbs. by hand pump test.....	330 gals.
Underwood, Ia.—		
	Pressure 45 lbs., elevated tank test.....	300 gals.
George, Ia.—		
	Pressure 45 lbs., elevated tank test.....2,500 gals.	
	This rate was reduced to.....	750 gals.
	(This line was reported to have had an open trench test made, when laid, showing all pipe absolutely tight before backfilling.)	
Pine Bluffs, Wyo.—		
	Pressure 80 lbs., stand pipe test.....	900 gals.
Donnellson, Ia.—		
	Pressure 45 lbs., elevated tank test.....	410 gals.
Lehigh, Ia.		
	Pressure 100 lbs., elevated tank test.....	445 gals.
	When extreme care was not used in closing the gate valves at the pump the leakage amounted to approximately...1,000 gals.	
Wanda, Minn.—		
	Pressure 45 lbs., elevated tank test, no measurable leakage	000 gals.
Colo, Ia.—		
	Pressure 45 lbs., elevated tank test,.....	294 gals.
	Previous to the repair of one or two leaks the rate had been.....	460 gals.

Jewell, Ia.—

Pressure 60 lbs., hand pump test, first line of mains ..... 340 gals.
Second line of mains..... 450 gals.

Numerous other tests have been made giving similar results. Part of the above work was constructed without definite leakage limit clauses in the contracts and in some cases the contractor was also engineer on the work. Taking all conditions and data into consideration, it appears that under normal conditions a maximum rate of leakage (average for an entire system) of not over 400 gals. per mile of pipe per 24 hrs. could be secured.

It is the writer's opinion that no water mains should be constructed without definite leakage limits the specifications and without definite leakage tests upon completion of the work. Large leaks even where the water is plentiful and cheap are certainly undesirable and under many conditions may not make themselves apparent at the surface of the ground. Where there is a scarcity of water it is almost imperative to avoid large leakage.

Individual Leaks Usually Small

Leakage in the amounts tabulated above seldom occur as but one or two large leaks, but usually represent numerous small seeps, some through the pipe joints, occasionally some through the valve stems, occasionally some through small defects in the pipe and some through the valves of the fire hydrants. Such leaks at the joints are too small and inaccessible to be detected by the ordinary instruments and where they do not show at the surface of the ground, if they are to be located at all it will ordinarily be necessary to go over the line systematically and dig down to the joints. Where gate valves have been placed at frequent intervals, the section of pipe wherein the greatest loss of water occurs can be easily determined by leakage or shrinkage tests. Very sensitive tests can be made by hand test pumps or with elevated tanks or stand-pipes.

Penalty and Bonus Clause in Contract

Where leakage does not exceed 650 gals. per mile of pipe per 24 hrs. it seldom softens the ground at the surface or otherwise gives surface indications. However, should it occur that this amount of leakage is principally in one or two places it may show at the surface in dense soils, such as clay. Such leaks will usually give indications at the surface of the ground within one or two weeks and some times within a few hours. Where the water supply is ample and the leaks do not show at the surface of the ground, the writer does not consider a loss of 650 gals. per mile per 24 hrs. as serious, but where the water supply is meager, say 15 to 50 G. P. M., the writer has often included in the specifications a light damage clause for leakage in excess of 425 gals. per mile of pipe per 24 hrs. and a corresponding bonus clause for leakages amounting to less than 425 gals.

THE USE OF CENTRIFUGAL PUMPS IN MUNICIPAL WATER PLANTS

By Russell A. Murdoch, C. E. Consulting Engineer, 706 Free Press Building, Detroit, Mich.

This article should be chiefly useful to those engineers who are called upon, from time to time, to choose the type of pump to be used where several types seem possible.

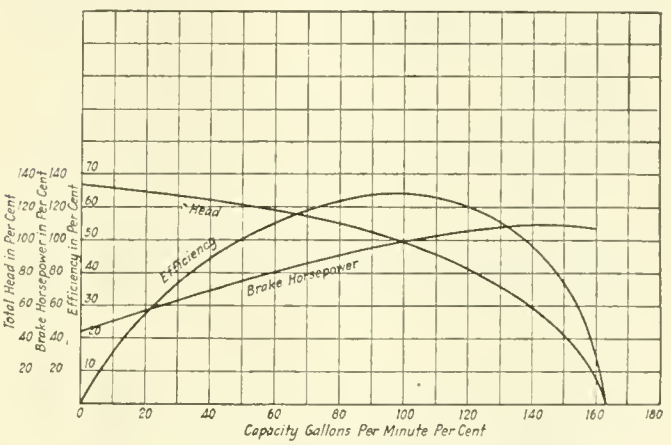
In dealing with this subject it will be necessary to touch slightly upon the power pump in general.

Power pumps are classed generally as follows:

(a) Reciprocating pumps; (b) rotary pumps; (c) centrifugal pumps.

A reciprocating pump is, as the name implies, one in which the water is displaced by reciprocating pistons or plungers. This necessitates the transformation of a rotary to a reciprocating motion, since the motion of power delivery of practically all prime movers is rotary.

A rotary pump is one which works by displacement produced by the rotation of two intermeshing cams, which, in the smaller sizes usually take the form of gears.



TYPICAL CHARACTERISTIC CURVES OF A CENTRIFUGAL PUMP, CONSTANT SPEED.

We may define a centrifugal pump as one in which the water is delivered due to the action of a rotary part (the impeller), causing the water to rotate in the casing and, by centrifugal force, due to its rotating motion, to be thrown outward to the spaces provided in the casing, whence it is delivered through the proper passages to the discharge.

Types of Centrifugal Pumps.

Briefly, we may outline the various types of centrifugal pump as follows: "Turbine." "Volute."

(1) Single suction.

(A) Open impeller. (a) Single stage, horizontal or vertical.

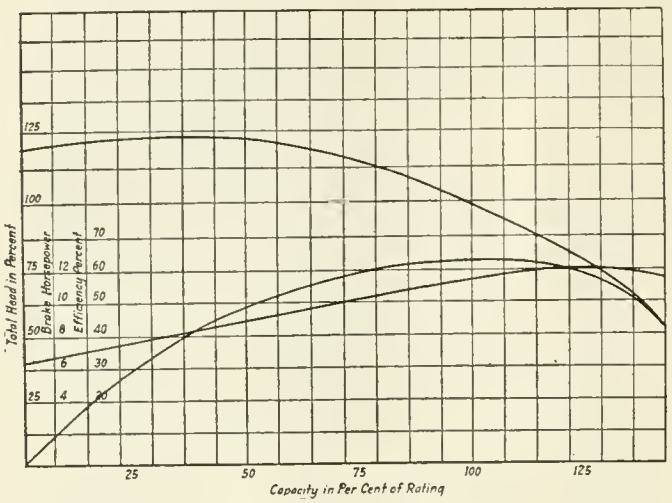
(B) Enclosed impeller. (a) Single stage, horizontal or vertical; (b) multi-stage, horizontal or vertical.

(2) Double suction. (A) Single stage. (B) Multi-stage.

The centrifugal pump is very well suited to certain classes of service. Designs have, within recent years, been worked out that would have been considered as utterly impossible 12 or 15 years ago.

Where, a few years ago, this type of pump was regarded as a rather interesting, but impractical scientific toy, good only for large volumes against low heads, and it was even stated by good engineers that its efficiency could never be over 25 to 30 per cent., public opinion has now rushed to the other extreme and many engineers and technical men (not to speak of laymen) demand a centrifugal pump for every installation, regardless of its suitability for the conditions of operation.

It is hardly necessary to say that such people have not the slightest conception of the theory and design of centrifugal pumps, and it is to be regretted that they are in such a large majority, as such a course of action is very likely to bring into disfavor one of the most useful types of pumping machinery we have.



TYPICAL CHARACTERISTIC CURVES OF A CENTRIFUGAL PUMP OPERATING AGAINST A MEDIUM HEAD, CONSTANT SPEED. RATED CAPACITY 700 G. P. M.

It is also to be regretted that there is probably more misunderstanding regarding the centrifugal pump today than there is in connection with any other piece of apparatus which is in equally common use.

Advantages and Disadvantages of Centrifugal Pumps.

Within its limits the centrifugal pump is extremely useful and has many advantages over any other type of pump. If its limitations are to be exceeded, however, it is far better not to use it at all, as nearly every advantage will be foregone and it is likely to prove a detriment to the installation.

Its principal advantages are:

1. Simplicity.
2. Compactness.
3. Low first cost.
4. Lack of reciprocating parts.
5. Good efficiency.

Its principal disadvantages are:

1. Lack of suction.
2. Sensitiveness to changes in speed and head.
3. General lack of knowledge of its characteristics among both consulting and operating engineers.

It is not fair to charge up against the apparatus the misrepresentation on the part of careless or unscrupulous manufacturers or salesmen, which are the cause of considerable dissatisfaction on the part of the purchaser, when the installation is finally completed, due to the incompatibility between the pump characteristics and the operating conditions.

The Action of Centrifugals.

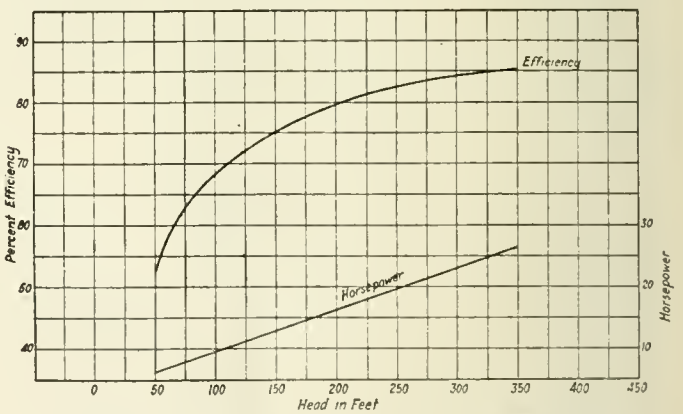
While it is not the intent of this article to go into the details of pump design, nevertheless it is not out of place to say a few words regarding the action of centrifugals, as they are becoming a more and more important feature of water works engineering as time goes on.

Since a centrifugal has no suction, if it is desired to actuate it automatically, it is evident that it must be installed with "flooded suction"— i. e., so that the water flows through the suction piping to the pump.

Foot valves and primers are sometimes used, but they are not entirely satisfactory, as they are too susceptible to leakage.

It is preferable to keep the suction lift of all pumps as low as possible, on centrifugals especially so. In the case of a plunger or reciprocating pump, high suction lifts may be compensated for in a measure by selecting a large-sized pump and running it at low speed, thus allowing the cylinders to fill more easily than would be the case if a smaller pump were run at a higher speed. With a centrifugal pump, however, this can not be done, as the speed (with a given number of stages) has to be suited to the discharge pressure required.

Neither is it economical to use a large diameter of impeller at a slower speed, as the impeller is, from elementary considerations, a water brake, and, since the brake action varies as the fifth power of the diameter of the impeller, it is evident that doubling the diameter increases the brake action 32 times, due to this increase. The brake action depends, of course, on the friction between the impeller and the surrounding water, and also upon the adhesion of the water to the impeller (which may be considered, naturally, in connection with the friction). Since the friction between two moving bodies in contact is a function of their relative velocity, it follows that the brake action is a function of the velocity of the impeller—i. e., its speed. But since the linear velocity of any point on the impeller depends upon the semi-diameter (radius) it follows that the brake action must



TYPICAL PERFORMANCE CURVE OF A SINGLE ACTING TRIPLEX PUMP, SIZE 7x10 INS. CAPACITY 250 U. S. G. P. M. CURVES BASED ON CONSTANT DELIVERY-VARIABLE HEAD.

be some function of the diameter. As a matter of fact the brake action of the impeller varies only as the square of the speed. Inasmuch as the brake action of the impeller is one of the internal losses of a pump, it is very evident that a small diameter and high speed impeller will be much more efficient than a large diameter impeller running at a slower speed, both delivering against the same pressure.

This explains why some manufacturers will bid upon a pump of more stages than others. They save the brake energy by using smaller impellers, the speed being also kept down by using more stages, and, consequently, obtaining less pressure per stage.

This fact explains why the efficiency of a centrifugal (or turbine pump) is not dependent entirely upon workmanship or design, as, by using a larger number of smaller impellers, the saving made by reducing brake losses may offset careless or improper design. Such a piece of apparatus may, of course, be cheaper, but it embodies more wearing parts and, while the material may be of the best, and the commercial efficiency high, nevertheless it would be a compromise to obtain the desired result.

Briefly, the pump which will do a certain work with the fewest number of stages with equal or less horsepower than another is of better design—i. e., its design comes closer to fulfilling the requirements. It is important to remember that this brake energy is not indicated in any way by the so-called "characteristic curves" of a centrifugal.

Formula.

The following facts may be briefly stated:

For a given impeller, (1) the capacity varies directly as the speed, (2) the pressure (mv^2) varies directly as

$$\frac{}{r}$$

the square of the speed, (3) the horse power

$$= \frac{\text{(foot pounds per min.)}}{33000}$$

$$= \frac{\text{gallons per min.} \times 8\ 1/3 \times \text{head in pounds} \times 2.3}{33000}$$

$$= \frac{K_1 \times \text{capacity} \times \text{head in pounds} \times K_2}{K_3}$$

$$= \frac{K \times K_1 \times K_2}{K_3} \times s \times s^2 = K_4 \times s^2$$

varies as the cube of the speed.

In the above

$K_1 = 8\ 1/3$ is the factor for converting gallons into pounds (weight)

$K_2 = 2.3$ is the factor for converting pounds into feet (pressure)

K_3 is the number of foot pounds in a horsepower (33000) per minute.

K_4 represents $\frac{K.K_1.K_2}{K_3}$

Where K is the combined proportionality factor between the speed and the capacity and pressure.

These are the same formulae as are used for steel plate fan computations.

Hence, by doubling the speed of a certain impeller it will deliver twice the capacity against four times the pressure, but it will take eight times the pressure to do it.

Since the maximum pressure developed by a centrifugal pump is independent of anything but the speed of the impeller, it follows:

(1) That it may be used to advantage to discharge into a closed system without fear of excessive pressure developing.

(2) The discharge valve may be shut off without harming the pump, (provided it is done so as to avoid water hammer.)

(3) When the discharge valve is closed, since the pump is delivering no water, theoretically the horse power equals zero, because, in the above formula, capacity equals zero; hence, the numerator of the fraction being zero, its value is zero. Practically, however, we have the brake action of the impeller and also the friction of the bearings, etc. This explains why the horse power curve does not start from zero at zero capacity.

In the above items are covered the principal inherent differences in action between a centrifugal and a positive displacement pump.

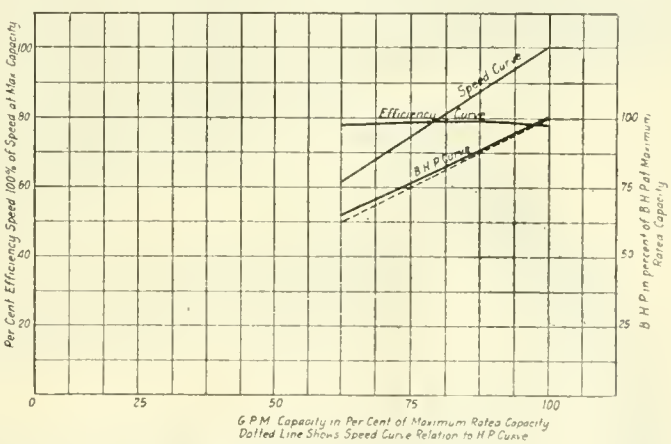
In the latter, any pressure (up to the safe working limit of the pump) may be pumped against at any desired speed, (and consequent capacity) provided the required horse power is available and provided the speed exceeds the R. P. M. slip. The centrifugal, on the other hand, is extremely sensitive to variations in:

(1) Speed.

(2) External resistance, i. e., variations in the discharge pressure or "counter pressure," because—

(1) Any variation in speed changes the delivery (capacity) accordingly and *also the pressure against which the pump will operate.*

(2) Since, at a given speed, the maximum pressure is fixed, it is evident that, if the external resistance be increased beyond a certain point, the pump will no longer deliver water, but will simply churn the water in the



TYPICAL CURVES SHOWING OPERATION OF TRIPLEX PUMP AGAINST CONSTANT HEAD.

Note—Data taken from Manufacturer's Bulletins. Type of Pump not Selected to Show Highest Possible Efficiency but rather with view of Obtaining a Typical set of Curves. The Efficiency of a Triplex Pump often runs between 80% and 85% Maximum.

casing. In fact, such a condition may be demonstrated by gradually closing off a valve in the discharge line. The discharge will gradually decrease as the resistance increases, until, at the point where the counter pressure equals the pressure developed, no water will be discharged.

Conversely, it is apparent that, if we have a pump delivering a certain capacity against a certain discharge head, and this head is *decreased* the delivery will be *increased*. As a matter of fact the increase will be rapid, more rapid than the reduction of head to which it corresponds.

Referring to the general formula,

(*Continued on page 258*)

lished reputation for ...ch service admi...
one argue against facts like these.

250 Years of Service at Versailles, France
210 Years of Service at Weilburg
165 Years of Service at Claremont, Ferrand
120 Years of Service at Glasgow and London
111 Years of Service in Baltimore
101 Years of Service in Philadelphia
100 Years of Service in New York

...ice C. I. P. & C. are busy saving money
...age railroads ... while C...

"In Cast Iron You Are Dealing With a Certainty"

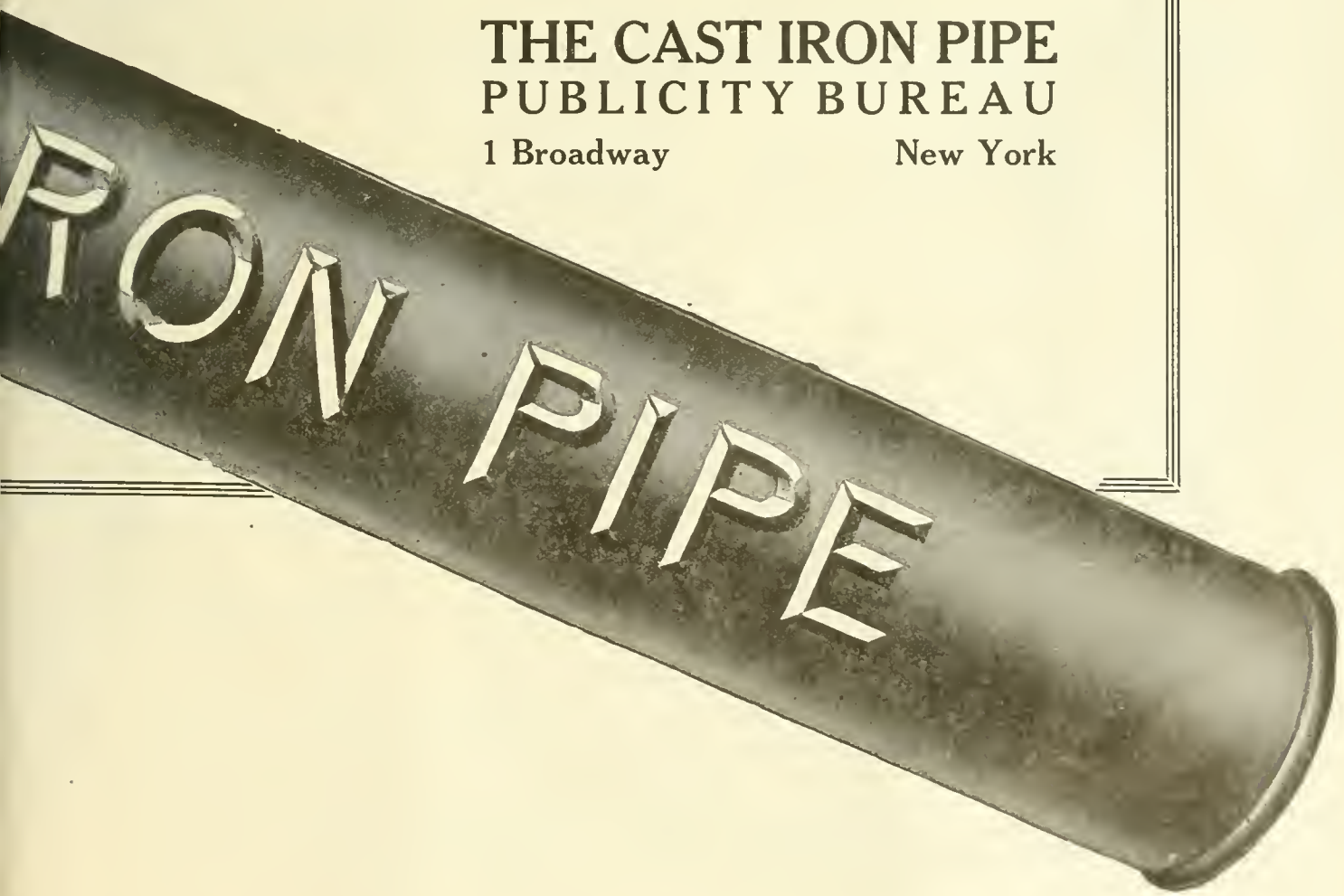
IF there is any uncertainty in your mind as to the wisest choice of pipe for underground work, reflect on these words of a well-known authority—

"In Cast Iron You are Dealing with a Certainty"

Pipe costs money—you know that, and also pipe which fails to render satisfactory service costs you more money—then it is but wisdom to invest in the pipe which for Centuries of Service have but proved its ability to render long faithful service, thanks to its being endowed by Nature herself with the preservative needed to Cure the Curse of Corrosion.

Chemists have their theories, but Nature has her laws, and it is the law of Nature which protects Cast Iron Pipe—yes, and the investments of all who install it. Remember that—and more, do not forget that this is fact, not theory.

THE CAST IRON PIPE
PUBLICITY BUREAU
1 Broadway New York



(Continued from page 255)

$$\text{H. P.} = \frac{8\ 1/3\ \text{G.P. M.} \times 2.3 \times \text{pressure in pounds}}{33000}$$

if the G. P. M. increases more rapidly than the pressure decreases, it is evident that the horsepower will be decreased.

This brings us to the most important development in the design of the centrifugal pump—i. e. the "non-overload" impeller.

By this term we signify an impeller of such form that, if the pump be designed to deliver a certain capacity against a certain head, and the head should, by accident or design, be reduced even to free discharge at the pump, the increase of capacity (the speed being constant) will be so regulated (automatically, by the design) that the load on the prime mover will not be increased beyond a certain point (usually about 10 per cent. increase) and may, beyond a certain point, actually be decreased. In other words the maximum horse power curve should be convex upwards, with a well defined maximum (see characteristic curves herewith). This feature is embodied, today, in the designs of nearly all manufacturers.

Relation Between Power and Speed.

There is a definite relation between the power and speed in connection with a centrifugal pump. The power required drops off more rapidly than the corresponding speed; hence, less power is required to drive the pump at slower speed, and, consequently, less current passes through the rheostat—e. g. since the horse power varies as the cube of the speed, at half the speed, one-eighth normal horse-power would be required. Further, neglecting the lowering in virtual resistance of the armature, due to slower speed, one-eighth the normal E. M. F. would be required at the terminals (actually, it would be less than one-eighth). This would mean seven-eighths of the E. M. F. would be applied to the resistance (rheostat), but, since, in a series circuit, the current is the same in all parts, one-eighth the normal current passes through it.

The loss in resistance is—$W = I^2R$

Where W equals watts power lost, I equals current in rheostat, R equals resistance of rheostat.

Hence, only one sixty-fourth of the loss takes place that would take place if the whole current were passed through the rheostat and armature.

Now, since the applied E. M. F. is the same (across motor and rheostat combined) always (neglecting variable voltage due to "regulation"), there is a greater loss when the full current (eight times as much) passes through the armature, whose resistance is only one-eighth of the combined resistance, for, the I^2R formula being true,

I^2 becomes 1 instead of 64 and

R is one-eighth;

hence, the I^2R loss may *roughly* be compared as being as one times one-eighth, as opposed to one sixty-fourth times one, or as one-eighth to one sixty-fourth—i. e. eight times as much.

The above is only very rough and neglects electrical losses, etc. in the motor; it also assumes that the current in the field of the motor remains constant while that of the armature changes. This is not true, as the shunt field and the armature are in parallel across the line. It will serve, however, to show that armature control of centrifugal pumps is far from being as wasteful as might be expected.

Attention may be called to the fact that some manufacturers rate their centrifugal pumps as requiring so much horse-power per 10 ft. of head. This is not correct.

In the first place the friction horse-power must be considered. In the second place the brake horse-power curve is not a straight line, but a curve. The horse-power per 10 ft. of head must, therefore, be only an approximate figure. The curves show typical forms and it will be evident from them wherein the error lies.

Automatic Control.

A few words must be said in connection with automatic control.

The pressure regulator should be used where the area of the water storage is small and the pipe is high making a large variation in the pressure, or, when a float switch would be likely to get out of working order by freezing or some other cause.

The float switch is very good where the area of the storage reservoir is very large and the change of pressure very small.

From the foregoing considerations and from the shape of the characteristic curves it is very evident that it is quite necessary to know as nearly as possible the exact condition under which a centrifugal pump is to operate in order to be able to select the proper pump for the service. This is to be borne in mind when dealing with the manufacturer of such apparatus as a conscientious and reputable manufacturer will hesitate to bind himself to assume any responsibility for the operation of a centrifugal pump unless he knows exactly the nature of the service for which it is intended.

If this detailed information is not forthcoming, he will make certain assumptions upon which to base his guaranties and recommendations. If the assumptions do not happen to be correct, confusion will inevitably result—either in connection with the tabulation of the bids, or else, when it comes to the final test of the apparatus for acceptance.

In either case it will be plain to all concerned that the responsibility rests with the engineer for his failure to supply the manufacturer with proper data.

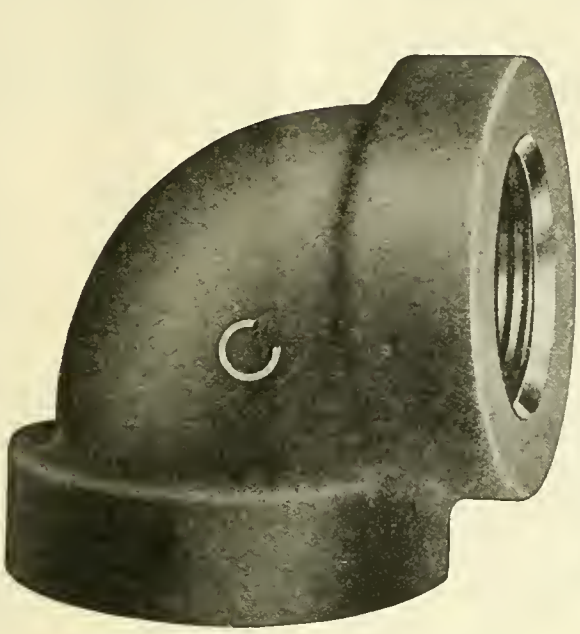
HOW TO AVOID BOILER SCALE

To avoid boiler scale, rather than remedy its evils, was long a problem with water rectification engineers. It is no secret that removal of the incrustation which hard water leaves on boilers and pipes has cost industry literally millions of dollars.

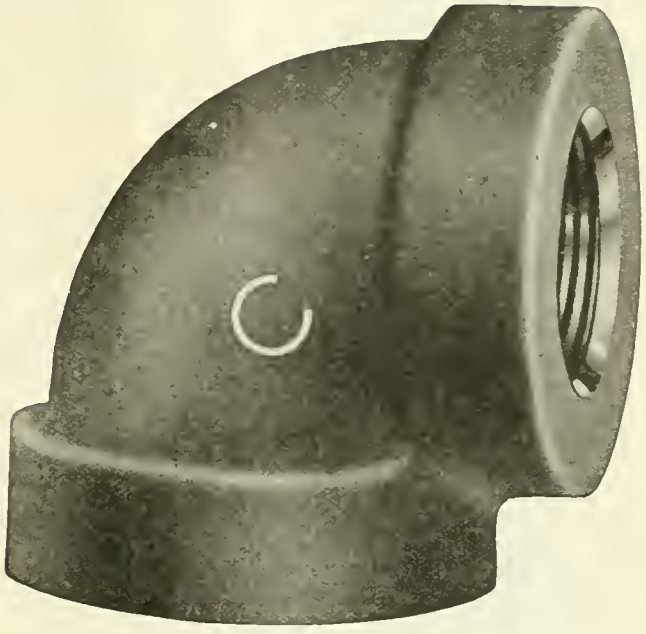
A few years ago experiments were began with a zeolite found in the Black Hills country of South Dakota. By the proper processing of this mineral, which has the property of exchanging sodium for the lime and magnesia salts present in water, it was learned that disintegration could be overcome and the life of the zeolite prolonged practically indefinitely.

(Continued on page 260)

A fitting that is stronger than the pipe



Elbow
3000 pounds pressure



Elbow
6000 pounds pressure

CRANE

FORGED STEEL

Screwed Elbows and Tees

These fittings are forged solid and then drilled and tapped for the required pipe size. Straight and reducing sizes can be furnished. Where a higher safety factor is desired we can furnish fittings made from larger blanks than regularly.

Recommendations:

For superheated steam;
Sizes ½-to 2½-inch—any existing pressure and temperature.

For extreme high pressure air lines;
Sizes ½- to 2½-inch—any existing pressure.

For ammonia and carbon dioxide lines;
Sizes ½- to 2½-inch—any existing pressure.

For Hydrostatic pressures;
Sizes ½- to 2½-inch—3,000 pounds pressure.
Sizes ⅜- to 2 -inch—6,000 pounds pressure.

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We are manufacturers of 20,000 articles—valves, pipe fittings, steam specialties, etc.—for all phases of power plant equipment, and are distributors of pipe and heating and plumbing materials.

24-inch line looking south from Dam, through Medicine Canyon.

30,000 Feet of 24-inch

"U. S." Bell and Spigot pipe laid through the roughest kind of country; hugh boulders, dips from 12 to 20 feet, and ALL WITHOUT A SPECIAL CASTING OF ANY KIND. The line has given excellent service, testifying the economy and advantage of the Bell and Spigot joint.

Cast Iron Pipe holds many service records in this country—112 years in Baltimore, 100 years in Philadelphia, 80 years in New York, etc.

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Buffalo—957 E. Ferry St.
Minneapolis—Plymouth Building.

(*Continued from page 258*)

That discovery meant that this zeolite, nature's own water softening mineral, could be turned to commercial use. There remained only the need of a suitable mechanical apparatus or system.

In steam power plants, central heating plants, institutions and similar industries the country over, this mineral is today removing from the feed water the properties which cause scale.

It has enabled these industries to prevent the enormous waste of fuel which scale causes, to save the time and labor ordinarily required in drawing fires and cleaning out the troublesome incrustations and to avoid the rapid depreciation of equipment which comes as a result of boiler scale.

The system, which is known as the Refinite Water Softener, consists of a container in which is a bed of the Refinite mineral or processed natural zeolite, and the necessary inlet and outlet valves. It connects to the line supplying water for the boilers.

Feed water enters the container at the top and passes through a bed of Refinite to an outlet. The simple natural exchange action takes place at this time. The water is rendered absolutely soft. There is nothing in it when it reaches the boilers that can cause scale.

Each system is built to soften or remove the scale-forming properties from a given number of gallons of water of a specified hardness in ten hours. Ordinarily at the end of that period the mineral is so saturated with lime and magnesia salts that it must be recharged. This is done by simply allowing a solution of sodium chloride (common salt water) to stand in the container over night. The following morning this is flushed out and the mineral is again ready for a day's run.

These systems are used extensively as well in textile mills, where water of no hardness is so essential; in machine shops, etc., and in homes. They require no expert supervision and their operation is entirely automatic.

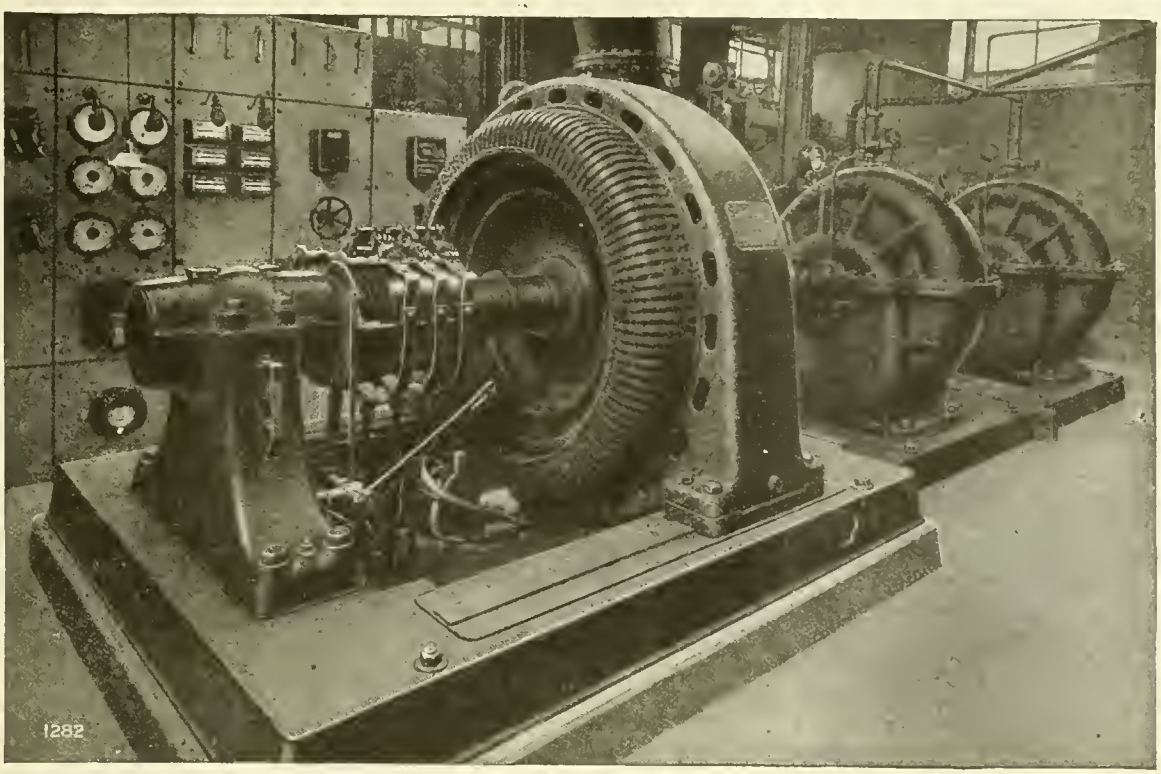
EXPERIENCES IN AN ARTESIAN WELL CONTRACT

By Jerry Donohue, Consulting Engineer, Sheboygan, Wis.

The writer has during the past ten years had considerable experience in making plans and specifications for water works installations in Wisconsin cities and villages where the population of the community was under 5,000. The cost of these systems ranged from $20,000 to $75,000. Under present conditions, however, many cities have been forced to abandon their water works plans because of the prevailing high prices of materials. This has created many new problems which engineers have had to meet by either decreasing the size of both distributing mains and storage tanks, or by eliminating other important parts of the system which towns will ultimately need. The one feature, however, which the writer feels should be carried out in spite of the prevailing high prices, is the drilling of wells, which are usually the source of water supply for cities of this class. How cities contemplating the construction of a water supply system

(*Continued on page 262*)

DE LAVAL



Two De Laval 24-inch pumps driven by three-phase induction motor. 30,000,000 gals. per day against 250 ft. head.

Each 1% of Efficiency
Worth Over $2,000 Per Year

THE two De Laval Centrifugal Pumps shown above deliver 30,000,000 gallons per day against 250 ft. head. At this rating, using power at two cents per kilowatt hour, 1% in efficiency amounts to over $2,000 per year.

As a matter of fact, the efficiency of these pumps is 82.5%, that is 5 to 6% above the best previous record. Full particulars will be supplied upon request.

The efficiency and capacity of De Laval Pumps is guaranteed, and a comprehensive test is made before the pump leaves the shop. This policy of testing, with the use of high grade materials, skilled workmanship and first-class shop facilities, has lead to a continuous improvement in pump efficiencies and to the maintenance of a high average.

If You are interested in Centrifugal Pumps
Ask for Special Publication B-92

DE LAVAL STEAM TURBINE CO.
TRENTON, NEW JERSEY

(*Continued from page 260*)

can start their program of construction under present conditions, is the problem before us at this time.

The necessity of getting the well drilled in advance of the construction of the remaining part of the system is best exemplified by reciting the history of a case that a small city experienced where the drilling of the well might have delayed the supply of water to the town, had not the community had the foresight to see the necessity of entering upon the part of the program well in advance of the general contract.

Well at Chilton, Wis.

The City of Chilton, Wisconsin, a city of approximately 2,000 people, located about 30 miles South of Green Bay on the Chicago, Milwaukee and St. Paul Railroad, discussed the need of water works for ten years before the community at large finally demanded that the city take some action. The City Council, therefore, in October, 1916, adopted plans and specifications covering the construction of a complete water works system, including the drilling of an artesian well; the installation of the distributing system, which also included two river crossings; the erection of an elevated steel tank of 80,000 gal. capacity; and the construction of a small pumping station to house the pumping equipment necessary to put the water from the artesian well into the elevated steel tank.

The contract for drilling the well was awarded in October, 1916, and the contract let to a well contractor who, in the opinion of the Engineer, had not qualified as an expert in well drilling, but who had the appearance of being a good, straightforward, persevering man, who would probably give the city good service if he did not meet with problems that were too much for him. The well section provided that an artesian well of about 900 ft. depth be drilled. Beginning with the 12 in. hole at the top the well was to be cased through the drift and the hole through the Niagara Limestone and the Cincinnati Shale was to be 10 in., then it was to be stepped down to 8 in. through the Galena and Trenton Limestone and the hole was supposed to stop after entering about 50 ft. into the St. Peter Sandstone.

The contractor's outfit consisted of the ordinary walking beam type of engine operated by gasoline, and he did not have any particular trouble in making satisfactory progress through the limestone and shale. The Galena Limestone, however, had pockets of sand, which appeared to open up excellent streams of water, but which offered considerable difficulty to the contractor, inasmuch as his drill would from time to time become lodged, requiring all of the power of his outfit to pull it.

Drill Becomes Lodged

At a depth of approximately 700 ft., the contractor's drill became lodged in the well, and he could not dislodge it by ordinary pulling. He had not had experience in dislodging drilling tools at that depth, nor did he have proper equipment immediately to loosen the drill. Undoubtedly, if he had had proper equipment on hand at the time of the trouble, he could have removed it, but either he was careless in not keeping his drill sharpened or the extraordinary conditions present in the well were the cause of this trouble.

Dynamite Fails to Explode

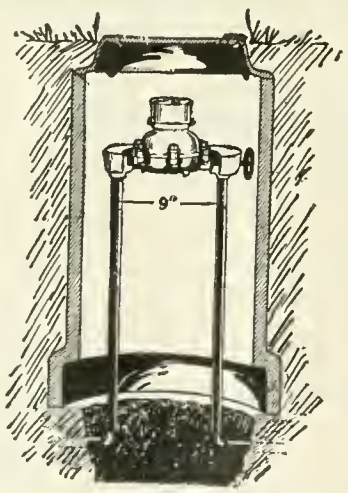
Finally it became necessary for the City to notify the Bonding Company to take charge of the work. They employed another contractor who had had experience in dislodging drilling tools and who had a heavier outfit. This outfit was brought upon the job and it also failed to dislodge the drill. Dynamite was then recommended and the second contractor, claiming to have had experience on dislodging tools by blasting prepared a cartridge of dynamite enclosed in a water-tight tube connected to an exploding cap, which tube was small enough to drop between the drill and the side of the hole. Everything worked fine until it become time to set off the charge and it was found after several attempts, that although the cap would explode each time, the dynamite would not explode and no reasons could be offered by the contractor for its failure to operate. The opinion of other experts was then called for and there appeared to be considerable difference of opinion, some claiming that there ought not to be any difficulty in exploding the dynamite at that depth and others claiming that it could not be done.

The best explanation was offered by the Chemical Department of the American Glycerine Company of Wilmington, Del. Quoting from their letter, they stated:

> We note that you have met with failure in attempting to explode dynamite 700 ft, under water and we are not surprised at this as water pressure at that depth is quite a hard thing to cope with and your failure is due to the fact that water at that pressure, cushions, so to speak, between the different

(*Continued on page 264*)

McNutt Meter Setting Specialties



As a result of our rigid policy of maintaining the highest standards of quality and service in **McNutt Meter Setting Specialties,** the demand for our equipment has grown so rapidly that we are now making the second addition to our factory facilities, within eighteen months. McNutt Equipment *makes good*—and we shall leave nothing undone that will improve our product and insure the service that users of McNutt equipment have come to expect.

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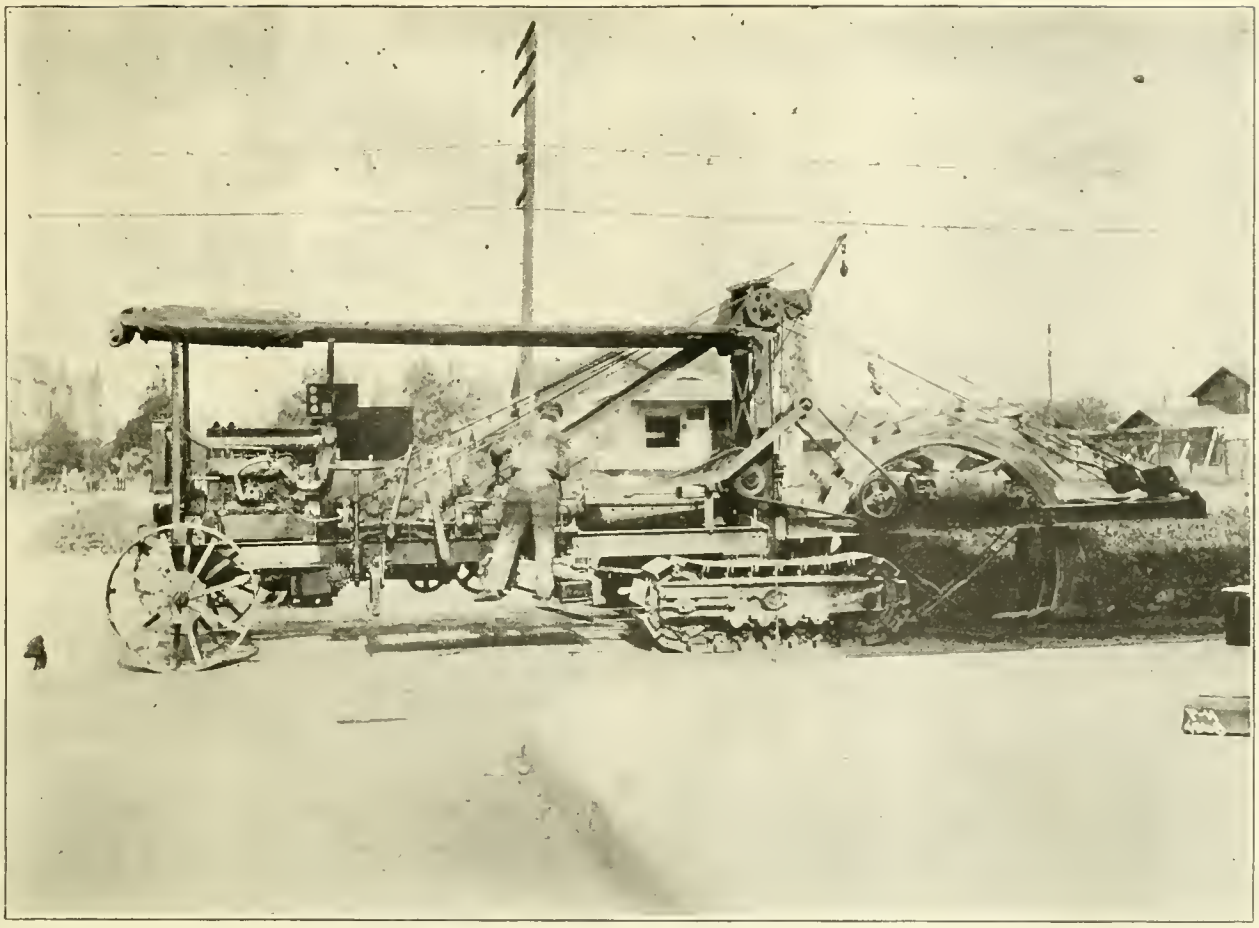

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Machine No.	Width of Cut	Depth of Cut
102	18 to 21 inches	5 feet 6 inches
103	18 to 24 inches	6 feet 6 inches
125	20 to 24 inches	7 feet 6 inches

Write or wire our nearest branch.

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"You see them wherever you go, and they go wherever you see them."

P&H — excavators — back-fillers - tampers

(Continued from page 262)

molecules of the explosive so effectively that there is not sufficient violence in the explosion of any one molecule to overcome the resistance offered by this cushion, consequently it cannot explode its neighbor molecule and as a result the explosion does not propagate. This does not affect the explosive in any way and upon moving this cushion as would be the case in taking the explosive to the surface again, the explosion would detonate the same as before being subjected to this pressure. You will find this difficulty to exist with all absorbed explosives and you cannot reasonably hope to shut out the water pressure at a depth of 700 ft. under water by means of tin or any thin material. When we get 200 lbs. pressure on a boiler, we begin to expect things, ordinarily, notwithstanding the fact that the boiler is made of heavy material.

Liquid Nitro Glycerine being an oily, compact liquid of practically 1.6 specific gravity is not affected by water pressure as are the absorbed explosives due to the fact that the water cannot penetrate the nitro glycerin; it is therefore our duty to advise you that you will find no other explosive than Liquid Nitro Glycerin, suitable for the work you mention.

We know of no source of supply for Liquid Nitro Glycerine nearer than the Aetna Explosive Company at Chicago, and it is possible you might procure some there. No doubt you are aware that this commodity cannot be transported by rail and it would be necessary to arrange to transport it by truck and if this is undertaken you want to provide especially against leakage and friction for it must be handled with care. This placed in a receptacle, leaving the top open so the water could get into the receptacle would be the proper way of arranging the material so as to lower it into the well, and since your letter indicates that you can explode electric exploders in the dynamite in the bottom of the 700 ft. well, we say that you could, of course, explode the exploders in the Liquid Nitro Glycerin, and for that reason would not consider it necessary to issue instructions regarding this matter except to ask that it be handled with due care and again repeat that you must provide well against leakage and friction.

The foregoing explanation appeared to be so reasonable that the Council decided to abandon the work altogether, for the obtaining of the necessary nitro glycerin involved an additional hazard which ordinarily cities do not care to assume. The city then decided to readvertise for bids on a new well, which was finally drilled about 7 ft. from the one giving all of the trouble.

This second well was drilled by a contractor familiar with deep well work and he successfully passed through the same strata which caused trouble to the first contractor, and although the drilling of the well was delayed about a year, the fact that the Council had awarded the contract a year in advance of the general contract, made it possible to connect up with the distributing system on schedule time.

Other small cities may profit by the experience of the city of Clinton in awarding their well contract a year in advance of the general system, for in addition to the hazard of trouble in the well, cities will find it desirable to have a water supply available for flushing their streets, which naturally will be torn up during construction. Furthermore, they will find it desirable to have their well tested before deciding upon the type of pumping equipment that they may select.

NEED FOR COMPREHENSIVE WATER AND SEWERAGE SYSTEMS

By John F. Druar, Consulting Engineer, 512 Globe Bldg., St. Paul, Minn.

If there are any two municipal utilities that are absolutely necessary in these days, it is comprehensive water and sewerage systems for all municipalities. Even in the smallest community of one or two hundred, as well as in our greatest cities, the need is urgent.

Rapidly reviewing some of these defects I have found in an investigation of some two hundred cities and villages, I find that there have been very serious faults in nearly all systems. Perhaps the engineer cannot be blamed for some of the apparent short comings, for he has had to work within the limit of the funds available and has not been able to stretch them indefinitely to meet even the ordinary requirements of good practice.

Laws Should Protect Small Cities Against Themselves

The legislatures of the different states must be blamed for not passing laws more favorable to the installation of water systems in small cities and villages. These laws should be drawn to protect a municipality against itself. No vote should be required by the citizens for bonds for such necessary improvements, but the council and other officers should be empowered to use their judgment backed by a careful report and plans and specifications of a thoroughly responsible and experienced municipal engineer for the installation of the system complete. The bond houses should be taken into consideration and the paper issued in payment for the improvement should be sold prior to the letting so that the contractor may be absolutely certain before he moves onto the work that the payments are forthcoming in cash when due. Such paper as is issued should have the full credit of the municipality behind it and draw a fair rate of interest so as to be attractive to the investor and so that no discounting of paper by subterfuge would be necessary.

In the present condition of affairs various states have different laws. In some the entire amount for which a municipality may be bonded is five per cent of the assessed valuation. The condition of the small towns of such states reflect this law. In Minnesota sewers may be installed up to practically no limit by resolution of the council and the cost assessed against the property lying in the sewer districts. This is a splendid law. It should be somewhat simplified and a law passed causing the installation of a municipal water works in the same manner but with the addition that the paper issued in payment should be made saleable; that is, more so than at the present time.

Federal Government Should Require Fire Protection and Good Sanitation

In fact, if a complete and comprehensive government study were made of the municipalities of the United States from a sanitary and fire protection standpoint, it would be found that if remedies were applied, there would be an enormous saving all along the line and it would pay to have some standard law compelling a

municipality to provide for its citizens such sanitary measures as might be necessary.

People, ever since the famous "Boston Tea Party," naturally hate to be taxed. Even when shown the necessity of improvements, certain elements of a population seem to feel that an improvement should not be made. This opposition is found among the retired farmer element as they, in many cases, have not had the improvements on the farm and maintain that what was good enough for grandfather is good enough for them. Then, there is the substantial man of affairs who has provided a private water and sewerage system at an expense of four or five hundred dollars, or even more, and he becomes opposed to it through selfishness and personal loss of his own system. He is too narrow minded to look to the welfare of his neighbors.

As such improvements generally call for a five-eighths vote to carry, it is at once apparent that if there is much opposition, the project will fail.

The near-sighted policy of the people is seen in not having had these utilities years ago for the cost is not great and the benefits many. The people fail to realize that the cost of building and maintaining an unsightly, crude, fly-breeding nuisance in the back yard, perhaps in close proximity to their dug well, and the cost of cleaning it several times a year, to say nothing of the periodical visits to this place of horrors in all kinds of weather, in sickness and in health is a thing they can not afford to continue even at great cost.

Economy of Sewerage Systems

As a matter of fact, an adequate sewer system can be installed in the average city or village of from five hundred to five thousand inhabitants by a direct assessment against the property abutting on the sewer in even these times for from $1.50 to $2.00 per foot front. In the last year, the cost on my work has been from $49.50 to $104.75 for a lot with a fifty-foot frontage. This amount can be paid in ten annual installments if it is desired with six per cent interest on deferred payments, or it can be paid up in full at the time the assessment is made. Thus at a cost of $100 or less per fifty foot lot, one may be relieved for all time of further cost or expense for the disposal of physical wastes and cellar drainage, as well as of the washing and cleaning water, etc.

Problem of Water Supply

Now the water problem is about the same. A community to be healthy and clean must have an adequate supply of clean, clear, pure and reasonably soft water in inexhaustable quantity, pure, as protected against contamination, and at a point where it will be economical to deliver it to the storage provided. In many cases, it is extremely difficult owing to the surrounding conditions to provide such a supply. Surface sources such as lakes, rivers and creeks are least satisfactory, as they all require treatment to protect the users against disease, and carelessness of the cleanliness of a water supply has sent a great many people to their death.

The problem of supply is one that must be given very careful consideration. If a large storage system is to be maintained, it is not necessary to have a large capacity source of supply, and on the other hand, if there is no opportunity for storage, then the per minute supply must be great. To supply the domestic requirements is not difficult, but in many cases, it is extremely difficult to store or provide by other means enough water to meet the standard requirements for fire protection as required by the National Board of Fire Underwriters. On this problem hinges the insurance rate of the municipality and

PROOF

THAT

THE NATIONAL METHOD

Cleans Water Mains

Note the number of contracts the following cities have entered into for **Water Main Cleaning.** These cities recognize the **economy, efficiency** and **necessity** of cleaning water mains by the **National Method:**

	Contracts		Contracts		Contracts
Boston, Mass.	5	Jersey City, N. J.	3	Rochester, N. Y.	7
Brooklyn, N. Y.	4	Little Rock, Ark.	3	St. John, N. B.	3
Cambridge, Mass.	5	Louisville, Ky.	5	St. Joseph, Mo.	3
Charleston, S. C.	4	Meridian, Miss.	3	St. Louis, Mo.	6
Cincinnati, Ohio	10	Newport, Ky.	5	Salt Lake City, Utah	5
Dayton, Ky.	3	Newport News, Va.	4	Shreveport, La.	3
Far Rockaway, N. Y.	5	Pittsburgh, Pa.	4	Uniontown, Pa.	3
		Suffolk, Va.	3		

Twenty-five cities have entered into second contracts and **one hundred** cities have entered into at least one contract for this work, in addition to the cities named above.

Write for booklet.

National Water Main Cleaning Co.

51 CHURCH ST. **NEW YORK.**

the savings that can be made in premiums for the people of a community.

Thus a carefully studied source of supply, storage and distribution system laid out for the future as well as for the present needs is the only true solution of a water problem.

The source of supply varies. It may be from deep wells, pumped to a surface reservoir by means of compressed air or deep well pumps. From this point, it can be relayed by electrically or steam driven pumps of greater mechanical efficiency to a reservoir on a hill of enough elevation to give a gravity pressure, or it may be necessary to build an elevated structure for the purpose of obtaining the same pressure. The supply may be obtained from shallow wells or drive points which should pass through a clay strata first so as to protect the underlying water from contamination from the surface. Again, the supply may be obtained from shallow wells of large diameter placed adjacent to a lake or river, the water being supplied by infiltration from the gravel strata.

In different parts of the United States, there is to be found an artesian flow, which, in many cases is strong enough, i. e., has enough head to produce the necessary pressure of 40 to 50 lbs. on the distribution mains and which allows a reservoir to float on the line at a given height. This may be controlled so as to keep the reservoir full at all times. For large works, sometimes the surface lakes of a territory are carefully protected and these with gravity flows become the reservoir system, but the surface supplies should be carefully treated and perhaps filtered before being sent into the distribution mains.

The problem of the supply of larger cities requires an enormous amount of work and an everlasting study for future development as is shown in the case of New York City and any of the largest cities in the country.

Distribution System

The distribution system should be of the gridiron type with numerous valves for the purpose of utilizing the maximum efficiency of the lines at all times even in the case of breaks. The reservoir or other source of supply. should be tied into the distribution system with two or more feeders if possible. All pumping equipment should be in duplicate with ample capacity in the duplicate units to take care of breakdowns.

In smaller systems, it is possible to design a closed system with pressure tank operation, but while I have designed many of these systems successfully, I would far rather have a gravity system as it is then not necessary to place all your reliance on the mechanical equipment. Very often pumps are operated by current obtained through a transmission line and if a breakdown occurs, and there is no gravity storage, the whole municipality might be destroyed through lack of pressure, in case of fire.

In the larger cities direct pressure is maintained on a closed circuit by means of pumps which by-pass such amount of water as is not being used in the system and a steady pressure is maintained in that way. Again special high pressure fire mains for river, fresh or salt water are used and the pressure and water is applied to the mains in case of fire only.

There are many combinations of the above that can be made applicable to the distinct problem, and in a short article it is impossible to touch on all of them. Suffice it to say that no town should be without a carefully thought out system, designed in such a way that it will not be a burden to maintain but one that will afford ample protection in case of fire, afford a good pure supply for domestic use and give all the citizens the advantage of the use of water.

Water Systems Are Economical at Present Prices

The cost of a water system at this time is high due to, primarily, the advance in the price of cast iron pipe. When one looks at the cost of a well in the door yard with an uncertain quality of water, which of necessity has to be pumped and carried in all kinds of weather and the cost of the installation of the pump and well and then finds that the cost of a water system in front of his property good for practically all time if properly installed for a 50-foot lot would be between $75 to $90 and that he can rely on it for fire protection as well and can obtain a ton of clean, pure, clear water drawn into his kitchen sink for probably less than 10 cents a ton, he is very likely to ask someone to kick him for being such a dolt as not to have discovered it before.

To be sure, he has to pay for a connection from the city main to his house for both water and sewer service and also for bath room fixtures, but the charge for connection to the house is but nominal while he can have as cheap or expensive fixtures in his house as he could wish.

I have endeavored in a short article to cover much ground and have tried to set forth the difficulties of the installation of water and sewers for the average municipality so that the layman as well as the non-technical city official may appreciate the vital importance of the subject.

How under the sun municipalities can and have done without water and sewer when they are vitally in need of them is more than I can understand.

Aside from the disposal plant or outlet for sewers and the well, pumping equipment and storage for water which is usually paid out of a bond issue, the individual lot owner would only pay about $200 for both water and sewer and could pay this at the rate of $20 per year for ten years. Such a system would be good for the next 60 or 70 years and it is up to the municipal engineer to go forth and educate the legislatures and public to the necessity of uniform laws for the purpose.

REMOVAL OF SULPHUR AND IRON FROM GROUND WATER IN OHIO

By George Champe, Consulting Engineer, 610 Nasby Building, Toledo, Ohio

The ground water supply of Northwestern Ohio is more or less charged with a sulphur and an iron content, the former causing an objection to the taste and odor of the water and the latter causing the deposit of the iron compound and a restriction of the carrying capacity of the distribution pipes and the coloration of plumbing by red water.

Reducing Sulphur Content at Leipsic, Ohio

Several years ago when the writer designed a concrete water storage reservoir for Leipsic, Ohio, an attempt was made to reduce the large sulphur content by conducting the well supply to the center of the circular reservoir and thence vertically to a point where it was discharged and passed by gravity to the reservoir beneath, through three circular trays, each perforated with ¼-in. holes, 1 in. apart. The trays were surrounded with wire

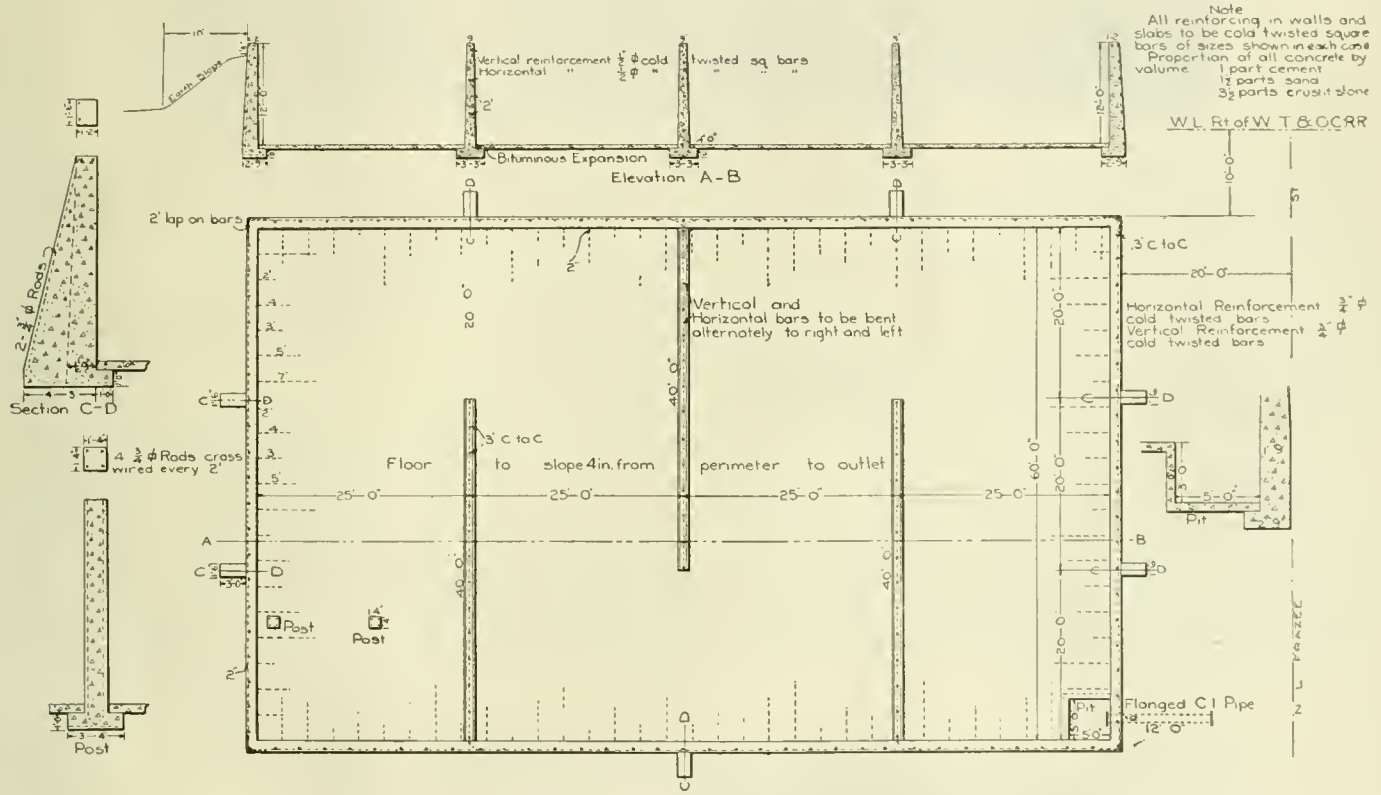
mesh of sufficient openings to afford a free circulation of air, but not large enough to permit the entrance of small birds. The original trays were constructed of steel boiler plate but were soon after replaced with wooden trays which have shown no evidence of deterioration, and establish the economical type of aerator of a water supply. Provision was made for discharging the material deposited on the bottom of the reservoir, periodically, through a sewer outlet.

Reducing Iron Content at Minster, Ohio

Afterwards, in designing a rectangular storage reservoir at Minster, Ohio, the aerator for the reduction of the iron content was placed at the extreme end from the outlet to the pump, and the supply was distributed over the uppermost tray through perforated horizontal galvanized iron pipes so that the water fell uniformly per cent reduction of the iron, or to a point where it is not objectionable. In this case there has been no replacement of the coke, and it is practically in its original condition of 1915. The process is mechanical, the purpose being to add as much free air to the water as the economical gravity operation will secure.

Reducing Sulphur at Bowling Green

At Bowling Green the water from five supply wells showed sulphur to the amount of 70 parts per million. Here the aerator was constructed of creosoted hemlock, and consists of a series of 15 trays, each 12 ft. by 12 ft. square. Hemlock was decided upon on account of the impossibility of securing a galvanized steel frame in time for the season's operation. The bottoms of the trays are ½-in. mesh, No. 15-gauge wire, heavily galvanized after weaving, and covered with 3 ins. of chestnut size fresh


Note
All reinforcing in walls and slabs to be cold twisted square bars of sizes shown in each case
Proportion of all concrete by volume 1 part cement 1½ parts sand 3½ parts crushed stone
W.L. Rt of W. T. & O.C.R.R.
Elevation A-B
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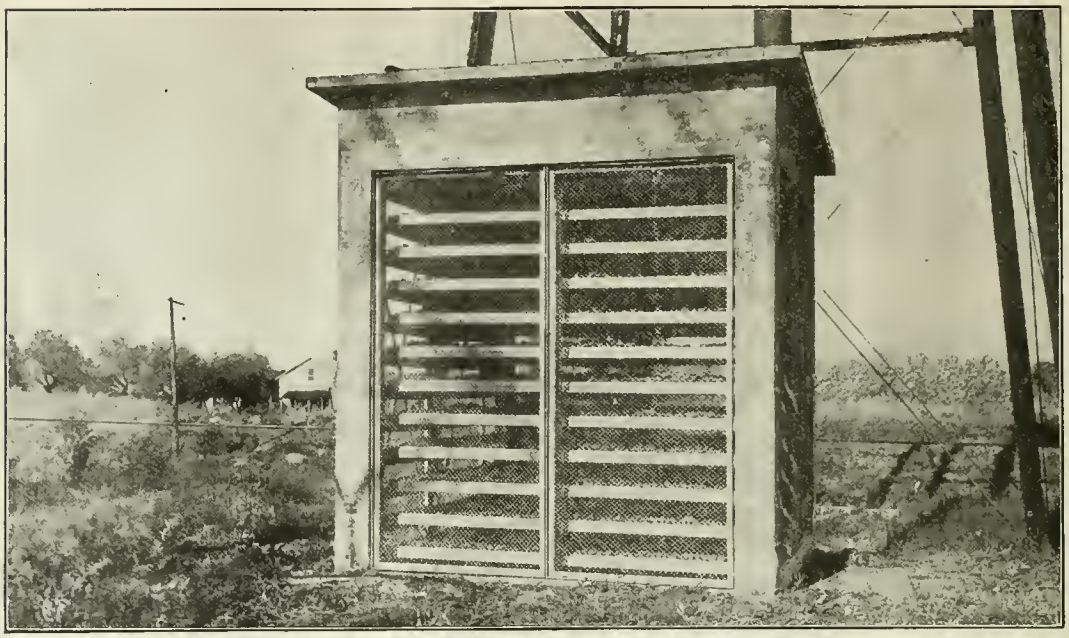
Vertical and Horizontal bars to be bent alternately to right and left
Horizontal Reinforcement ¾" ϕ cold twisted bars
Vertical Reinforcement ¾" ϕ cold twisted bars
Floor to slope 4 in. from perimeter to outlet
Section C-D
Post
Pit
Flanged C.I. Pipe

DETAILS OF WATER STORAGE RESERVOIR AT BOWLING GREEN, OHIO.

over the area of the upper tray. Twelve square trays were built, each consisting of a galvanized steel frame, with bottom of galvanized iron mesh, this in turn covered with 4 ins. of Connellsville coke, crushed to a diameter of 2 ins. An air space of 4 ins. was left between the bottom of each tray and the coke beneath. Provision was made for the removal of the trays and the replacing of the coke, but not more than two changes have been necessary since the installation in 1912. Twice yearly the deposit is washed from the bottom of the reservoir through the storm water sewer connection.

Reducing Sulphur and Iron Content at Maumee, Ohio

In the installation of the municipal water works system at Maumee, Ohio, an aerator of similar form to that at Minster was constructed for the reduction of both the large sulphur and iron content. In this case there is an entire elimination of the sulphur with approximately 75 Connellsville 72-hour coke. Distribution from the discharge pipe above the aerator is secured by an extra wooden-bottom tray, perforated with ½-in. holes. After one season's operation the coke on the trays is in practically its original condition. The sedimentation and storage reservoir is of 500,000-gal. capacity to overflow, being 60 ft. by 100 ft. in area, and 12 ft. deep, depressed 4 ft. into the earth, and banked on the outsides with excavated material. All concrete in floors and walls, consist of 1 part cement, 1½ part cement, 1½ part sand, and 3½ parts crushed stone, varying in size from ¼ to ¾-in. Sufficient water was used to secure a mixture that would flow in the forms with the least possible excess of water, and special care was exercised to prevent sloping surfaces in the fresh concrete that would cause a separation of the coarser material, and result in seeping walls. Three baffle walls, staggered, and extending to within 20 ft. of the opposite outside wall and to the full height



VIEW OF AERATOR AT MAUMEE, OHIO.

of the reservoir, provided for sedimentation over the entire reservoir area. At the close of the first season the floor of the reservoir was covered with a thin layer of light-grayish deposit.

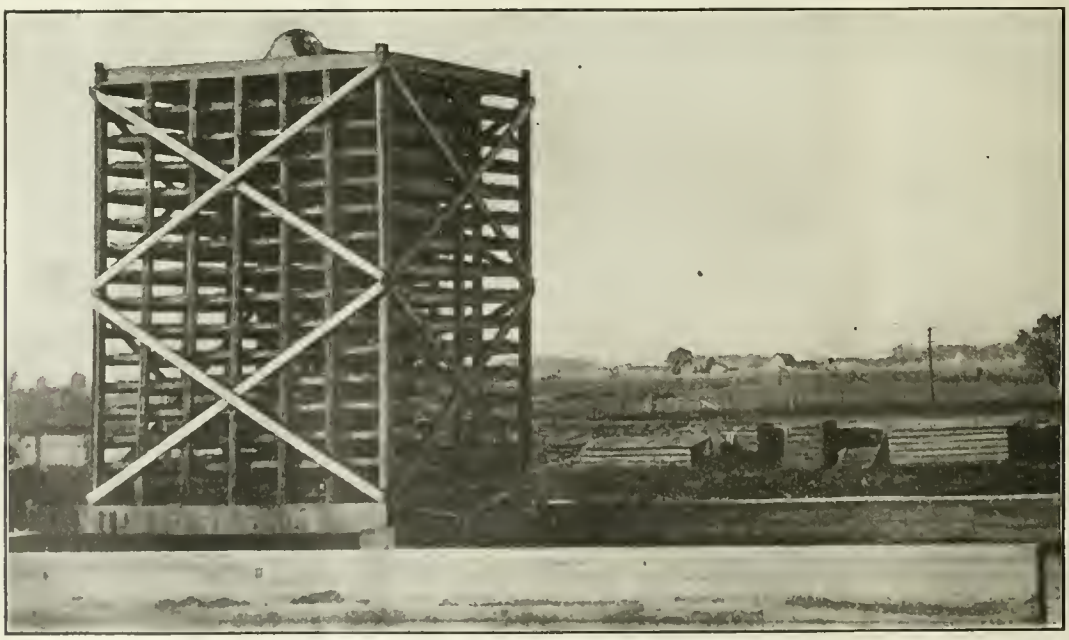
USING MOTION PICTURES IN THE DETROIT STREET RAILWAY BOND ELECTION

Motion pictures were successfully employed at Detroit recently in helping to win the election held to vote on the issuance of fifteen million dollars in bonds for the improvement of the street railway system of that city. The city proposed to take over the present street-car system and to build many new lines and the voters were asked to provide the money. As usual, there was considerable opposition to this project.

Shortly before the election it was decided to utilize moving pictures and the Rothacker Film Manufacturing Company of Chicago was selected to make the film. The pictures were exhibited in the Detroit theaters shortly before the election. Up to the time the pictures were introduced into the campaign the advocates of the bond issue were doubtful as to the result of the election. The election carried, however, by a safe margin and many Detroit citizens stated that in their opinion the pictures proved to be the deciding factor.

The pictures consisted largely of animated drawings visualizing the present Detroit situation as well as the proposed improvements. Cartoons of street-cars were shown moving across the screen to illustrate the roundabout way in which some citizens must now travel in going to work. The waste of time was emphasized and

(*Continued on page* 271)



VIEW OF AERATOR AT BOWLING GREEN, OHIO.

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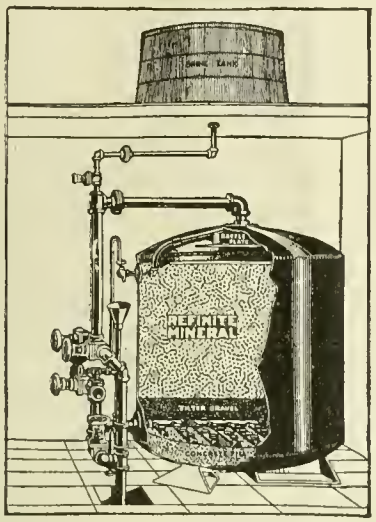

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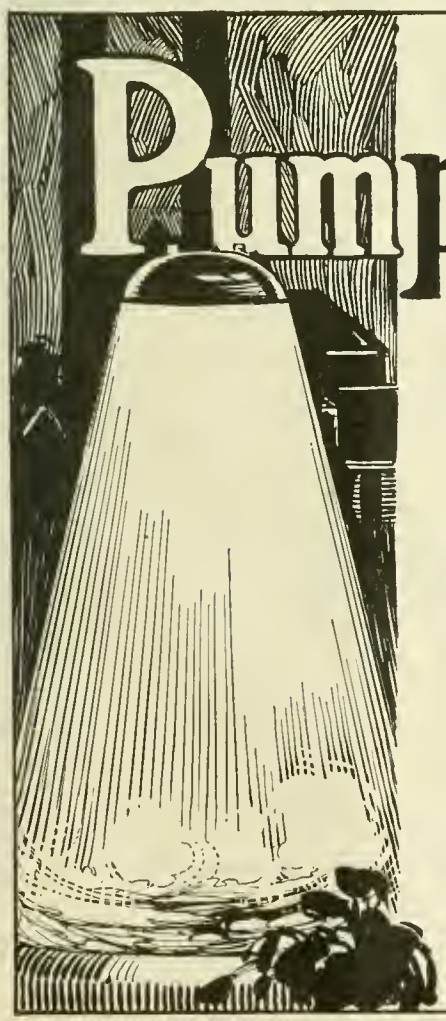

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(*Continued from page 268*)

attention was called to the number of transfers many workers now have to make in going to and from work. Of course, these matters were quite familiar to citizens of Detroit, but when these cartoons were shown on the picture screen they lead to a determination to correct the existing conditions.

Between animated drawings of the present system there were shown on the screen, at frequent intervals, Detroit street scenes showing the present crowded condition of the cars. Then followed animated drawings of the many new lines which fifteen million dollars would build. These new lines will take the citizen, regardless of his place of residence, to his work in most cases without even one transfer.

The success of this picture was such that a street railway company in another city is now planning to have the same film company make a picture for its needs. At the present time this railway company is not receiving a sufficient fare to maintain the present service, to say nothing of building the new lines which the city needs and wants. This street railway company aims to show the citizens of its town what a fare increase would enable it to give in the way of improved service.

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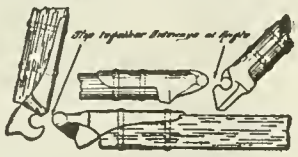

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CONSTRUCTION NEWS AND EQUIPMENT

A MOVEMENT TO DECREASE THE HAZARDS IN THE CONTRACTING BUSINESS

Certain proposed contract provisions, designed to take some of the "gamble" out of the contracting business have been brought out recently by a strong committee of the Associated General Contractors of America. The provisions number 16, and it is recommended that they be included in all future contracts. Criticisms and suggestions are invited from contractors, engineers, manufacturers and others interested in the subject.

The Hazards of Contracting

An analysis of income tax returns shows that contracting is the most hazardous industry in the country. They show that the amount of loss for every dollar of profit made by construction corporations is eight times as great as it is in manufacturing, agriculture, or personal service corporations; five times as great as in transportation and public utility corporations; over three times as great as in mining and quarrying; and nearly twice as great as in banking.

The reasons for this condition are due to the unusual number of doubtful elements in construction with which a contractor must work. It is unnecessary to enumerate them. They are all too familiar. It is sufficient that the more such uncertainties can be eliminated, the lower will be the costs of construction to the owner, the more satisfactory will be the relations of the architect the engineer and the contractor, and the more will contracts be awarded on a basis of skill, integrity and responsibility. Never was this more true or action on it more needed that at the present time.

From the very nature of construction many of these uncertainties can never be eliminated. They must either be assumed by the contractor or the owner. Some which are now assumed by the contractor ought by right to be assumed by the owner. Other uncertainties may be eliminated entirely to the advantage of both parties. The improvement of present contract provisions is one of the simplest solutions for this problem.

It was with these thoughts in mind that the Committee on Contracts of the Associated General Contractors of America, during the past year made a study of 113 different forms of contracts of various types. The committee is not prepared at this time to submit a complete form of contract embodying every position which should be included in a good contract. The members have, however, approved the following provisions which they recommend be included in every contract made by members of the Associated General Contractors of America. Additional provisions will be submitted from time to time.

Proposed Contract Provisions

1. Action on Bids—Bids should be submitted with the provision that they must be acted upon within a reasonable time.

2. Freight Rate Changes—Bids should be submitted on the basis of existing freight rates, with the provision that in case a change in rates should occur between the time bids are received and the date fixed for the completion of the contract, the contract price should be increased or decreased accordingly.

3. Wage Scale Changes—Bids should be stated and be submitted on existing wage rates, with the provision that the contract price shall be increased or decreased in accordance with any change in such rates before the date fixed for the completion of the contract.

4. Material Price Changes—Bids should be submitted on the basis of existing prices for materials f. o. b. the producer's plant or distributor's yard, with the provision that the contract price shall be increased or decreased in accordance with any change in such price that takes place within the time allowed the contractor to purchase and fabricate his materials.

5. Monthly Estimates—Monthly estimates should include materials delivered and suitably stored as well as materials incorporated in the work.

6. Partial Payments—Certificates should be prepared and delivered to the contractor between the first and tenth day of each month, showing the proportionate part of the contract price earned during the preceding month. These certificates should be paid by the owner by the tenth day of the month. Interest on deferred payments should be paid the contractor at the prevailing rate.

7. Contractor's Right to Stop Work—Under the following conditions the contractor should have the right to stop work or terminate the contract upon three days' written notice to the owner and the architect, and recover from the owner payment for all work executed and any loss sustained upon any plant or material and reasonable profit and damages:

(a) If the work should be stopped under an order of any court, or other public authority, for a period of three months, through no act or fault of the contractor or any one employed by him;

(b) If the architect or engineer should fail to issue the monthly certificate for payment in accordance with the terms of contract;

(c) If the owner should fail to pay the contractor, within seven days of its maturity and presentation, any sum certified by the architect or engineer or awarded by arbitration.

(d) If the owner does not permit the contractor to proceed with construction within a reasonable time after signing the contract.

8. Retained Percentage—The retained percentage

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should be based on 100 per cent. of the work performed and should never exceed 10 per cent. When the amount retained reaches a total sum, which shall be mutually agreed upon by the owner and the contractor, no further reduction from payments should be made.

9. Surety Bond—Where a surety bond is given, it should be reduced at agreed intervals so as to cover thereafter only that portion of work then uncompleted.

10. Penalty Clauses—Wherever any provision is incorporated in the contract for a penalty against the contractor (including liquidated damages), there should also be inserted provision for a bonus of like amount.

11. Acts of God or Public Enemy—The contractor should not be held liable for results arising from the acts of God or a public enemy.

12. Time Allowed for Completion of Work—The time allowed for the completion of the work should be based on "weather working days" instead of an elapsed time, and, if necessary, allowance should be made for time spent in performing unproductive work made necessary by floods or other natural causes beyond the control of contractor.

13. Inspection—Where practicable, materials should be inspected at the source so that costly delay may not result from the rejection, at the site of the work, of materials furnished in good faith by the contractor.

14. Force Account Work—Payment for force account work should be made on the basis of the total actual costs of the work, including the actual labor and material costs, rental on equipment, liability insurance, etc., plus a reasonable percentage to cover overhead and profit, total to be not less than 15 per cent.

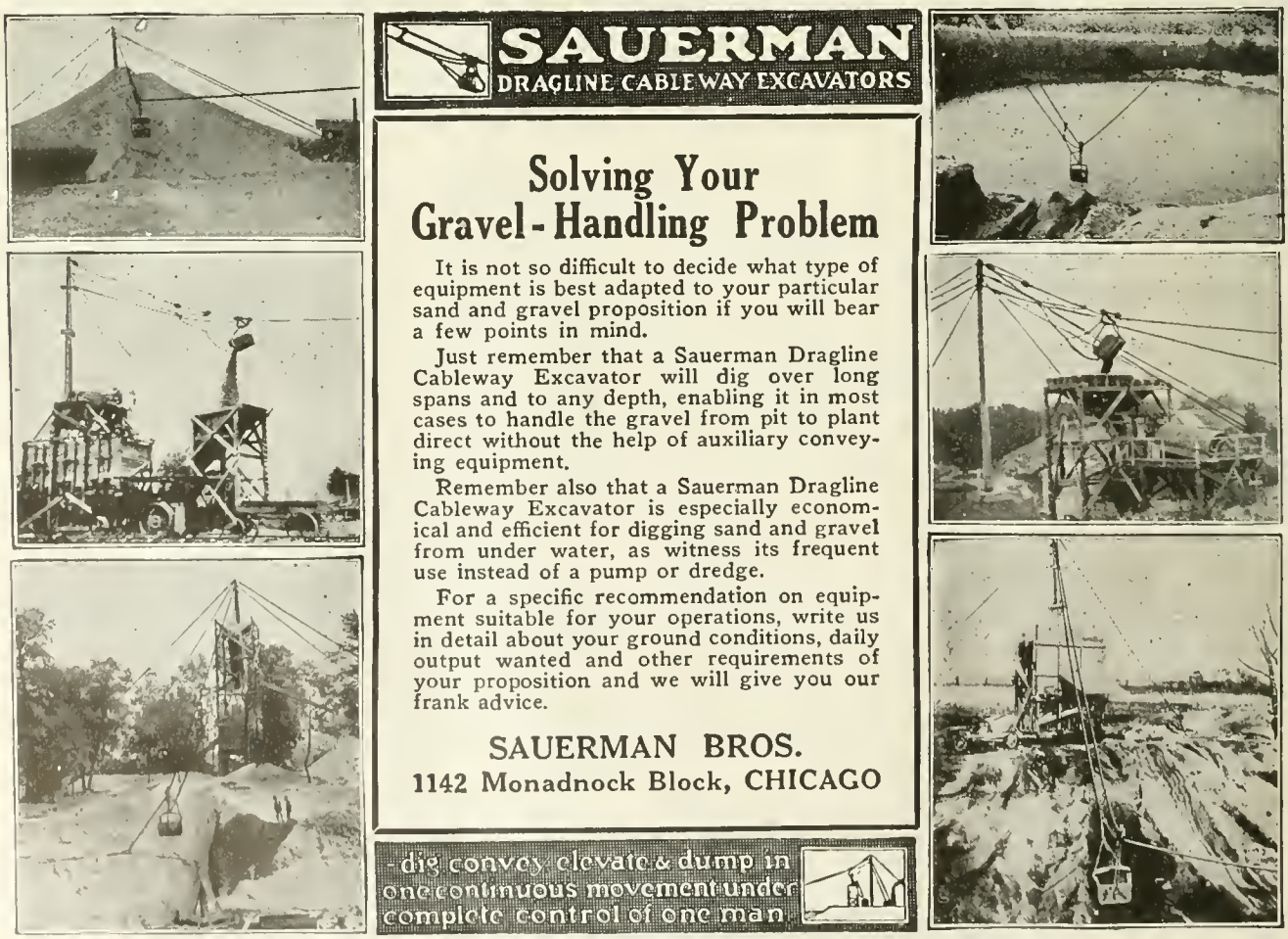
15. Change in Quantities—In case the actual quantities of any item in a unit price contract are less than the estimated quantities by more than a certain fixed per cent. the unit price paid the contractor for that item should be increased by an amount to be agreed upon. Similarly, a decrease in the unit prices should be made in case the quantities are increased over the estimate by more than a certain fixed per cent.

16. Arbitration—In no case should the engineer or architect be made the final judge as to the interpretation of the drawings and specifications or the performance of the contract. All decisions and interpretations should be subject to prompt arbitration at the choice of either party to the dispute.

Personnel

The personnel of the committee formulating these proposed contract provisions is as follows:

J. W. Cowper, Chairman, John W. Cowper Co., Buffalo, N. Y.; Arthur Bent, Bent Brothers, Los Angeles, Cal.; M. L. Cunningham, Municipal Imp. Co., Oklahoma City, Okla.; Avery Brundage, Chicago; V. T. Goggin, Fred T. Ley & Co., Inc. Springfield, Mass.; L. S. Oakes, Winston Brothers Co., Minneapolis, Minn.; J. W. Rollines, Holbrook, Cabot & Rollins, Corp., N. Y. City. and E. Stanley Holland, Bates & Rogers, Construction Co., Chicago.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Just remember that a Sauerman Dragline Cableway Excavator will dig over long spans and to any depth, enabling it in most cases to handle the gravel from pit to plant direct without the help of auxiliary conveying equipment.
Remember also that a Sauerman Dragline Cableway Excavator is especially economical and efficient for digging sand and gravel from under water, as witness its frequent use instead of a pump or dredge.
For a specific recommendation on equipment suitable for your operations, write us in detail about your ground conditions, daily output wanted and other requirements of your proposition and we will give you our frank advice.
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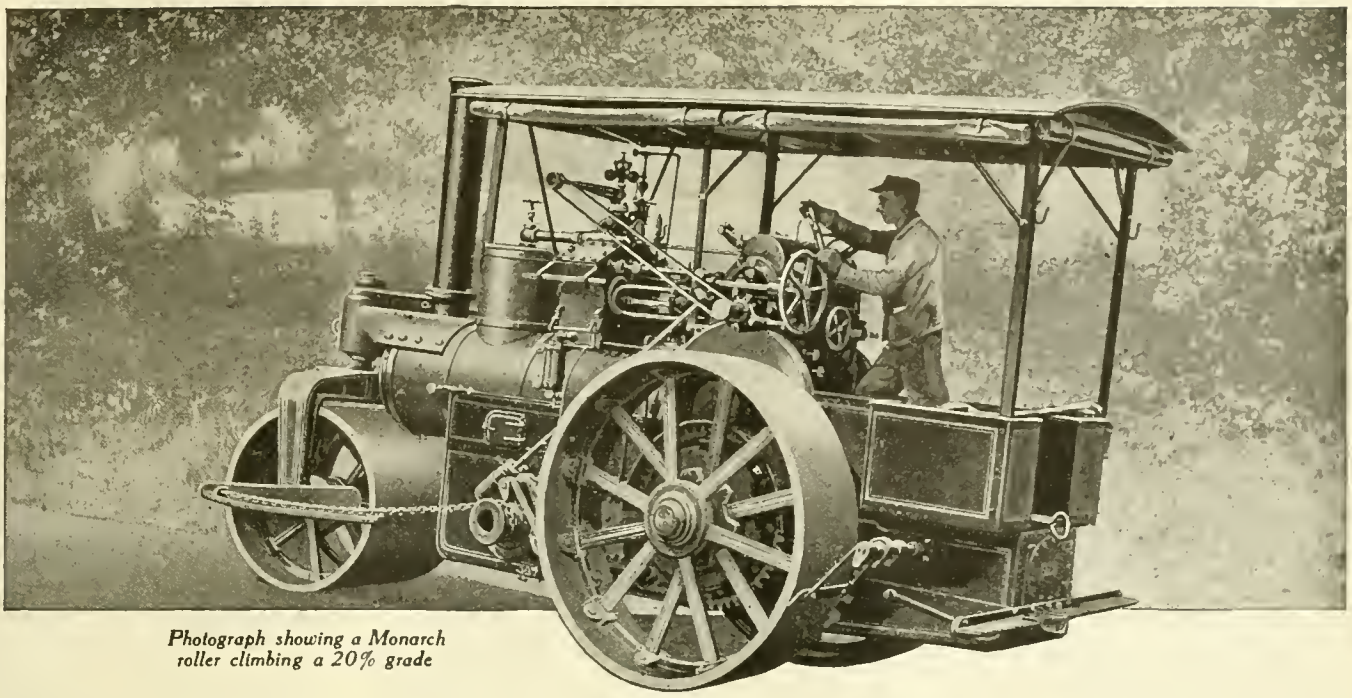

Photograph showing a Monarch roller climbing a 20% grade

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The GOOD ROADS Machinery Co., Inc.

"Everything for the Roadmaker"

CHOOSING THE TYPE OF PUMP AND THE SIZE OF PIPE ON CONSTRUCTION JOBS

By R. E. S. Geare, General Sales Manager, The T. L. Smith Co., Chicago, Ill.

Jobs where the hourly payroll runs into hundreds of dollars have been known to be held up hours merely because of the eccentricities of that all important, but seemingly insignificant pump. Yet delays which have cost the entire price of the pump at each occurrence have not seemed to impress upon the contractor the importance of actually knowing in his own mind what to look for in a pump.

Preventing Pump Shutdowns.

A simple method of guarding against these costly shutdowns is suggested as follows:

Look your pump over for mechanical defects at least once a week. A new bolt or nut may avert a hundred-dollar shutdown later.

Oil it regularly.

Be sure that the weight of the discharge line is not borne by the pump. Brace it or support it firmly.

With a force pump, place a foot valve with drainer in the suction line submerged in the source of water and valve in the discharge line.

In the case of a centrifugal pump, a hand or steam primer should be provided which should be connected to the top priming hole in the casing. Fill the casing with water *before* starting the pump.

Before you start on a new job figure out whether your present pumping equipment is capable of delivering the required capacity against your total lift and friction head.

Choosing a Pump.

This last suggestion is important—vital. There has always been something mysterious about the actual figuring of pump capacities which has prompted contractors to pass up all attempt at arriving at actual and definite figures. What would we think of a contractor who just blindly picked out a concrete mixer without regard to his requirements and then proceed to dump ingredients promiscuously into the drum without rhyme or reason, and expect to get satisfactory results? He would be eliminated from the ranks of the contractors very soon.

Yet did you ever stop to consider that this is about the basis on which a great many pumps are bought, even among successful contractors? If the contractor does not know about pump capacities or friction heads he asks somebody, anybody usually, or worse still, he guesses at it. Why does this condition exist? Is the average contractor a poor business man? Decidedly not, the $500,000,000 industry in which some 70,000 men are making money proves that. Is he naturally shiftless or inaccurate about such things? The idea is absurd in view of the great feats of construction he has accomplished. Here is undoubtedly the reason: the contractor is a busy man, he is doing big things and thinking big thoughts. That pump seems like an insignificant thing, a mere detail, and so it is if it is properly selected. But it assumes enormous significance when it fails to function in the manner intended.

Don't Forget Pipe Friction.

Recently a contractor secured a paving contract. Immediately he began buying his equipment. The last two items were 15,000 ft. of 2-in. pipe and a pump, in the order named. He had an elevation of only 60 ft. but a 15,000-ft. run to the job, and he wanted 45 gals. per minute at the end of the pipe line. His lift was only 60 ft., but his friction head was over *750 ft.* Think of wasting twelve times the actual head in friction. The pressure was so great that the pipe couldn't even stand the strain and he was forced to install two heavy duty pumps—one to pump half way to a tank and another to relay the water the remainder of the distance.

The moral is this: If he had only figured the friction head he would have discovered that by installing larger pipe he could have gotten the desired amount of water with one small duty pump, instead of two heavy duty pumps, and at a considerable saving of time and money.

Another example of the danger of guess work in getting a correct supply of water is illustrated by an instance which recently came to the writer's attention. In the case in point the contractor located a splendid supply of water at a distance of about 1,000 ft. from his job with a nice incline running down toward him. He thought this slope was decidedly fortunate for him—as indeed it was, had he understood conditions a little more thoroughly.

He decided to let gravity do the work and promptly installed 1,000 ft. of 1-in. pipe to carry the water to the job. When the line was completed he was amazed to find nothing more than a mere trickle of water coming through the end of the pipe. He had neglected to account for the friction which developed as the water passed through the pipe and out down the flow.

He was finally forced to install a pump actually to force the water down the incline. His only other alternative would have been to tear up all of his 1-in. pipe and replace it with another line of larger diameter.

This particular case was not a pump problem at all, or at least it should not have been. A clearer understanding of the subject would have saved this contractor the price of many pumps.

It is very simple to get just the exact pump for each particular job, and it is the object of this article to give in brief form a few simple directions and tabulations which will enable any pump user to figure exact size of pump necessary.* If this information is not already available in convenient form we would suggest that the contractor file this data where it can be referred to when the occasion arises.

The Uses of Various Pump Types.

At the start it might be well to explain the uses to which each particular type of pump is best adapted This may seem elementary, but it has been observed that inefficient operation is frequently traceable to the wrong kind of pump being used for the work. Diaphragm or splash pumps are designed for pulling purposes only. They have no pushing power and therefore their scope of operation is limited to the suction head only. This type is generally used to empty sewers, ditches, etc. Its lift is generally limited to a maximum of 25 ft.

Centrifugal and plunger type pumps are to be used where a lift and push are necessary. These two pumps

* These directions and tabulations are taken from the book "Never Failing Water," issued free by the T. L. Smith Company, 473 Old Colony Bldg., Chicago, Ill.

TABLE I—FRICTION OF WATER IN WROUGHT AND CAST IRON PIPES

Frictional heads at given rates of discharge in clean wrought iron pipe. (Inside Diam.) for each 100 feet of length.

U. S. Gal Per Minute	U. S. Gal. Per 24 Hours	¾ In. Pipe Friction hd.		1 In. Pipe Friction hd.		1¼ In. Pipe Friction hd		1½ In. Pipe Friction hd.		2 In. Pipe Friction hd.		2½ In. Pipe Friction hd.		3 In. Pipe Friction hd.	
		Feet	Lbs.	Feet	Lbs.	Feet	Lbs.	Feet	Lbs.	Feet	Lbs.	Feet	Lbs.	Feet	Lbs.
5	7200	7.59	3.30	1.93	.84	.71	.31	.27	.12	....	....	....	....	....	....
10	14400	29.90	13.00	10.26	3.16	2.41	1.05	1.08	.47	....	....	....	....	....	....
15	21600	66.01	28.70	16.05	6.98	5.47	2.38	2.23	.97	....	....	....	....	....	....
20	28800	115.92	50.40	28.29	12.30	9.36	4.07	3.81	1.66	....	....	....	....	....	....
25	36000	.....	....	43.70	19.00	14.72	6.40	5.02	2.62	1.18	.51	....	....	....	....
30	43200	.....	....	63.25	27.50	21.04	9.15	8.62	3.75	2.09	.91	....	....	....	....
35	50400	.....	....	85.10	37.00	28.52	12.40	11.61	5.05	2.76	1.20	....	....	....	....
40	57600	.....	....	110.40	48.00	37.03	16.10	14.99	6.52	3.68	1.60	1.19	.52	....	....
45	64800	.....	....	.....	....	46.46	20.20	18.74	8.15	4.60	2.00	1.49	.65	....	....
50	72000	.....	....	.....	....	57.27	24.90	23.00	10.00	5.61	2.44	1.86	.81	.80	.35
75	108000	.....	....	.....	....	129.00	56.10	51.52	22.40	12.23	5.32	4.14	1.80	1.70	.74
100	144000	.....	....	.....	....	.....	....	89.76	39.00	21.75	9.46	7.36	3.20	3.01	1.31
125	180000	.....	....	.....	....	.....	....	....	....	34.27	14.90	11.24	4.89	4.57	1.99
150	216000	.....	....	.....	....	.....	....	....	....	48.76	21.20	16.10	7.00	6.55	2.85
175	252000	.....	....	.....	....	.....	....	....	....	64.63	28.10	21.75	9.46	8.85	3.86
200	288000	.....	....	.....	....	.....	....	....	....	86.25	37.50	28.68	12.47	11.54	6.02
250	360000	.....	....	.....	....	.....	....	....	....	....	....	45.21	19.66	17.84	7.76
300	432000	.....	....	.....	....	.....	....	....	....	....	....	64.53	28.06	25.76	11.20
350	504000	.....	....	.....	....	.....	....	....	....	....	....	....	....	34.96	15.20
400	576000	.....	....	.....	....	.....	....	....	....	....	....	....	....	44.85	19.50
450	648000	.....	....	.....	....	.....	....	....	....	....	....	....	....	57.50	25.00
500	720000	.....	....	.....	....	.....	....	....	....	....	....	....	....	70.84	30.80

fill somewhat the same purpose, yet their distinction is clearly defined.

Where a small quantity of water is required at a high pressure the plunger type should be used, as under these conditions the efficiency of this type of pump is very high. If a large quantity of water is required the centrigal type of pump will operate with good efficiency at a comparatively low head.

The basic consideration in figuring pumping capacities and heads, is friction. Just as any two metal surfaces coming in contact with each other develop friction so does water passing through a pipe and rubbing the sides

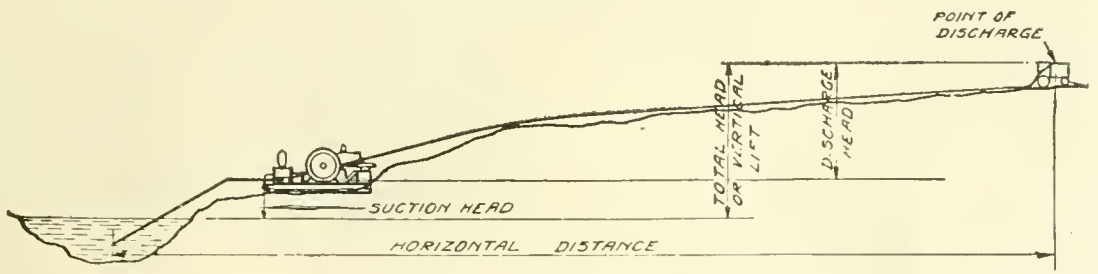


DIAGRAM ILLUSTRATING THE HYDRAULIC ELEMENTS INVOLVED IN PUMP AND PIPE LINE COMPUTATIONS.

develop the same condition. The friction acts as a retardant which keeps the water from flowing freely through the pipe, and it is the function of the pump to supply a force at one end of the line which maintains the flow at the other.

To explain clearly the power necessary to overcome this feature of friction let us assume that we wish a flow of water at the rate of 100 gals. a minute. If we lay a 2-in. pipe for a distance of 100 ft. and connect one end to a big tank of water we shall receive a flow of water in proportion to the height of the water in the tank. In order to exert sufficient pressure upon the line to deliver the flow at the necessary rate of 100 gals. per minute the height of the water in the tank will have to be exactly 21.37 ft. above a line from the center of the pipe. If the water in the tank were to recede to, say 12.23 ft., the pressure would have correspondingly diminished to a point where the friction in the pipe permits a flow of only 75 gals. a minute. On the other hand, if the amount of water in the tank was increased to 34.27 ft., the flow would become increased to 125 gals. per minute. Intermediate pressures will, of course, vary the flow proportionately. Complete friction tables are given herewith, see tables I and II.

On a line where it is impossible to get this pressure to push the water through the pipe by natural means, such as outlined above, it is necessary to attach a pump for the purpose. Here, as in the case of the water tank, as the pressure exerted by the pump is increased the flow of water is correspondingly increased.

To figure the horse power necessary, refer to the friction tables given and proceed as follows:

Example of Necessary Computation.

We wish, for example, to elevate 100 gals. of water per minute to an elevation of 100 ft. through 200 ft. of 2-in. pipe with two elbows and one valve in the pipe, the pump having an efficiency of 60 per cent.

Example:

100 (Elevation)
+ 43.5 (Friction in 200 ft. 2-in. pipe — double the friction in 100 ft. 2-in. pipe.)
+ 3 (Friction in two elbows.)
+ 1.7 (Friction in one valve.)

100 + 43.5 + 3 + 1.7 = 148.2 total head.

TABLE II—FRICTION OF STANDARD PIPE FITTINGS

The following equivalent length of straight pipe should be added for each fitting in figuring friction.

Size of Fittings	¾	1	1¼	1½	2	2½	3	4	5	6
Elbows	5	5	6	7	7	10	12	18	25	30
Return Bends	10	10	12	14	14	20	24	36	50	60
Globe Valves	6	6	7	8	8	12	24	30	40	50

Owing to the burr (caused by cutting the pipe with wheel cutter) obstructing the flow in the smaller pipes, it is advisable, unless the burrs are reamed out, to multiply the above figures, by 3 for ¾ and 1 inch fittings and by 2 for 1¼, 1½ and 2 inch fittings.

100 (Gallons per minute.)
× 8.33 (Weight of 1 gal. of water.)
× 148.2 (Total head.)
÷ 33,000 (33,000 lbs. elevated 1 ft. in 1 minute equals one horsepower.)

100 gpm × 8.33 × 148.2 = 3.74 theoretical horse power.

$$\frac{33{,}000}{}$$

3.74 ÷ 60 (efficiency of pump) = 6.2 actual H. P.

And finally, when you desire to use a pump on a new job proceed along the following lines, it will pay you every time.

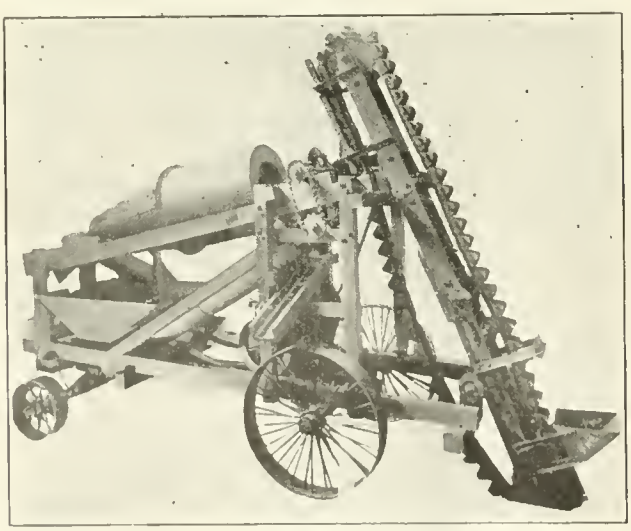
1. Assure the flow of water you want at delivery end of pipe.
2. Consult friction table and pick out the size of pipe which, for your total head, is about right.
3. Add your vertical lift from water to delivery level to the friction head for the size of pipe picked out.
4. If the total head, vertical lift plus friction seems excessive, go to the next size larger pipe.

A NEW PORTABLE SAND AND GRAVEL WASHER

Development of a portable sand and gravel washer, that meets the needs of contracts for light road work, is announced by the Link-Belt Company.

The new machine is not intended to replace permanent plants, but satisfies a demand for a small device which can be moved from bank to bank on road work and contracts where permanent plants are not readily available, and the gravel must be taken from small deposits.

The portable washer consists of an elevator, preliminary scrubber, screen and sand dewatering device, all mounted on heavy wheels with broad tires. The elevator is equipped with heavy steel buckets mounted on



VIEW OF NEW LINK BELT PORTABLE SAND AND GRAVEL WASHER.

single-strand chain. The elevator frame is constructed so that it can be folded up when the machine is to be moved. A small hand winch is provided to handle the elevator when it is to be folded or unfolded.

Mounted on the same shaft as the screen, and divided into compartments, is the Dull type of patented scrubber, which has lifting vanes or paddles on the inner circumference of the shell. These are so arranged that the material is thoroughly agitated and washed before it enters the screen. The screen itself is arranged to divide the material into one grade of sand, one grade of gravel, and remove the oversize.

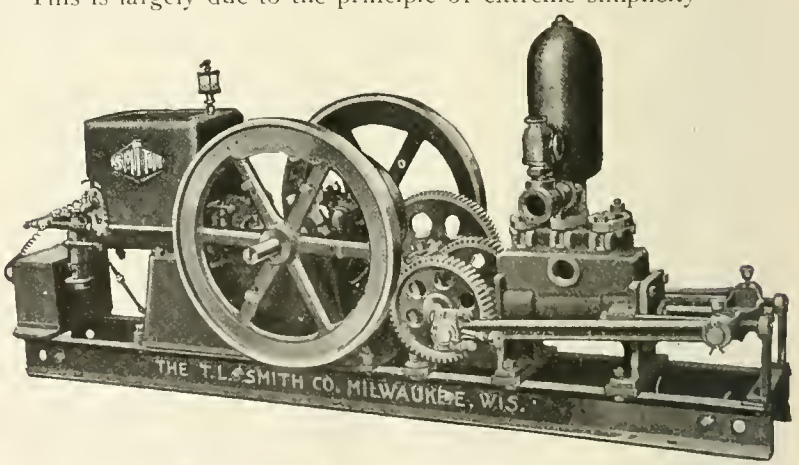
After passing through the screen, the sand and water are deposited into a settling tank, and the sand is dewatered by means of a heavy screw conveyor.

A gasoline engine mounted on the same frame supplies the power for the plant. The machine has a normal capacity of about 10 cu. yds. of pit-run material per hour.

BOOK ON PUMPING FOR CONTRACTORS AND ROAD BUILDERS

Pump users will find the pamphlet, "Never Failing Water," an interesting and instructive piece of literature in which the subject of pumps is treated in an exhaustive manner. Contractors and road builders will find it interesting because it contains pump statistics on uses in connection with paving machinery. It shows by example how to figure the size of a pump necessary to supply a certain quantity of water from any specified distance. It shows the friction loss developed by the passage of water through pipes of various sizes. It has a set of statistics showing the amount of friction caused by pipe fittings such as elbows, bends, valves, etc. Handy charts show at a glance the quality of water contained in rectangular or circular tanks of various dimensions. In addition it gives some valuable operating hints which will enable the user to get more efficiency out of his pumping outfit.

The book tells, too, about the complete line of Smith pumps, which includes force, diaphragm and centrifugal outfits of various sizes. Smith pumps have made a good reputation by their record of consistent performance. This is largely due to the principle of extreme simplicity



TYPE OF SMITH PUMP USED BY CONTRACTORS AND ROAD BUILDERS.

on which they are constructed. Fewer working parts are used and the design of the pump is such that any part can be removed without dismantling other parts.

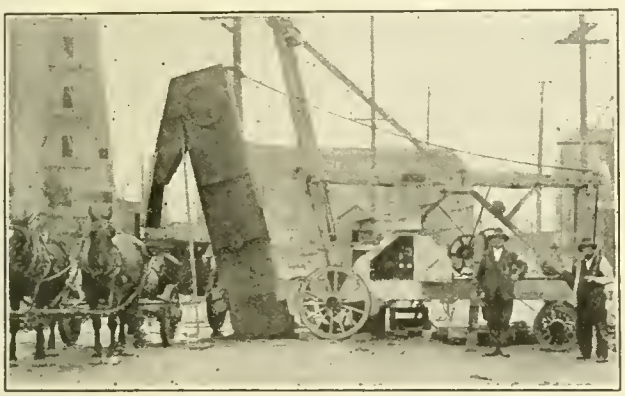
The Smith high pressure force pump is the only double-acting force pump with a double train of gears which has the jack bearings cast integral with the pump. This construction insures perfect and permanent alignment of the shafts and cross head pinions, a very important feature

and one which contributes greatly to the long life of Smith pumps. The book, "Never Failing Water," will be gladly sent free to interested parties. Write the T. L. Smith Company, 472 Old Colony Building, Chicago, Ill.

SAN FRANCISCO SEWER DEPARTMENT DESIGNS BUCKET ELEVATOR FOR CLEANING SEDIMENTATION CHAMBER

A bucket elevator was recently constructed under the supervision of Mr. M. M. O'Shaughnessy, City Engineer, San Francisco, Calif., primarily for the purpose of cleaning out a sedimentation chamber. The machine is illustrated herewith and Mr. W. H. Ohmen, Assistant Engineer, writes as follows of its successful use:

The sedimentation chamber for which this excavator was primarily designed is 10 ft. 6 ins. by 12 ft. 6 ins. and is approximately 1,400 ft. long. This is part of the main trunk sewer which is a combined storm and sanitary system. During the storm periods the sediment accumulates through this entire chamber to the height of the center



VIEW OF BUCKET ELEVATOR AS BUILT AND SUCCESSFULLY OPERATED BY CITY ENGINEERING DEPARTMENT OF SAN FRANCISCO FOR CLEANING OUT A LARGE SEWER SEDIMENTATION CHAMBER.

partition, 4 ft. high. After the rainy periods we drop the bucket excavator down one side of this sedimentation chamber and divert the flow to the other side by means of a dam at the inlet.

This device has proved very satisfactory. Under the old system of handling by bucket and windlass an average of about 4 yds. per day was all that could be obtained, but with the excavator in service we are getting out at least 28 yds per day, and when supplemented by longitudinal conveyor, which we have in mind to place on the partition wall in the center of the sedimentation chamber, we will probably accomplish twice as much work with it. This outfit cost approximately $2,300 and was designed to adapt itself to an old truck which belonged to the department. The elevator is designed to be supported from the cables at the center of gravity so that when raised it is easily tipped over and placed in a horizontal position on top of the truck for conveying through the street.

LITTLEFORD

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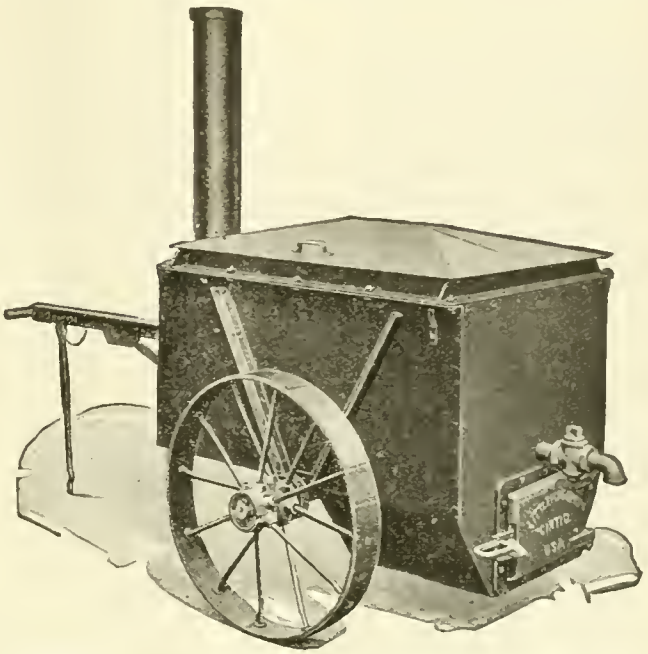

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LITTLEFORD Portable Tar and Asphalt Heaters are used by municipalities and leading contractors everywhere and are giving continuous satisfactory service.

Have you seen the LITTLEFORD Patrol Heater No. 68, a handy heater for the highway patrolman? Write for our circular describing this and other equipment.

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LITTLEFORD BROS.

460 E. Pearl Street
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Contracts Awarded

ROADS AND STREETS

Ala., Bessemer—J. F. Morgan & Co., awarded contract for paving 22 blocks, asphaltic concrete, at $269,566; Long & Hagerty, contr. to pave alleys with brick, at $22,500.

Ala., Birmingham—Road grading contracts involving 63½ miles of road awarded as follows: Pat Wallace, $49,235, 10 mi. betw. Warrier and Rebins cross-roads; $23,560, 3 mi. betw. Palos and Praco; $41,560, 5 mi. grading betw. Warrior and Coaldale, $10,560, 2 mi. Sadler's Gap; J. A. Dabbs, $72,175, 8 mi. betw. Oak Grove & Adger; A. F. Bearden, $80,154, 8 mi. Rocky Ridge rd.; $27,875, 2½ mi. betw. Irondale and Pole Cat Gap; Acton & Self, $27,905, 5 mi. rd. betw. Trussville and Acmar; Kershaw Constr. Co., $31,190; 5 mi. rd. betw. Clay and Trussville; J. B. Rylant, $14,700, 3 mi. Mt. Pinson to Center Point Rd.; John & Ira Parson, $14,020; 3 mi. rd. betw. Pleasant Hill & Morgan.

Ariz., Phoenix—Twohy Bros., Spokane, awarded contract by Commrs. of Maricopa County for following, at their bid of $4,000,000: grading & paving with one-course Portland cement 170 miles of highway to width of 16 ft. This is total of 1,500,000 sq. yds. 6-in. concrete paving.

Ark., Rison—Jno A. Perdue, Pine Bluff, awarded contract to constr. 10 miles Calmer Road, at $104,000.

Cal., Napa—Randome-Randall Co., 28th and Poplar Sts., Oakland, awarded contr. for constructing 11.6 miles conc. road betw. Rutherford and Calistoga, Napa Co., at $171,000.

Cal., Sacramento — Geo. S. Benson & Sons, Stimson Bldg., Los Angeles, awarded contract for paving with concrete 10.7 miles of state highway in Yolo Co.—Woodland to Zamora—at $140,889.

Cal., Sacramento—Riley & Peterson, (W. F. Riley, 2245 National Ave., San Diego; H. H. Peterson, Calexico), awarded contr. for paving with conc. 11.3 miles of state hwy. in San Diego Co. betw. Flinn Springs to Ogden Ranch, at $177,529.

Cal., San Diego—Kier Constr. Co., San Diego, awarded contract for paving Lemon Grove Rd., No. 4, at $160,723.

Cal., Woodland—Clark & Henery Constr. Co. Ochsner Bldg., Sacramento, awarded contr. for paving first unit of Yolo Co. Hwy. system, 10.7 miles, at $226,441.

Conn., Hartford—Immick Co. State St. Meriden, awarded contract by State Hwy. Comn., for bldg. 9,000 ft. hwy. 3-in. bitum. macadam on broken stone base, Wallingford Twp., at about $70,000; 5,100 ft. Howe Ave. asph. on 6-in. conc. base, Shelton Twp. to Conn. Hassan Paving Co., 920 Chapel St., New Haven, at $80,000.

Del., Dover—Keystone State Constr. Co., Commercial Trust Bldg., Phila., awarded contract for bldg. 4.14 miles Townsend-Pine Tree-Odessa Rd., 16 ft. wide, at $240,072.

Ida., Rexburg—Gibbons & Reed, Salt Lake, awarded contract for 12 blks. street paving, ten blks. of sidewalks and 12 blks. of gutters, at approx. $170,000.

Kans., El Dorado—Meredith Co., El Dorado, awarded contract to pave sts. in Florence, at about $100,000.

La., Covington—Lawrence, Nixon & Phillips, Jackson, Miss. and R. S. Daniels, awarded contract to surface 33.5 miles of road with gravel, at $218,000. Mr. Daniels located in Covington, La.

Md., Chestertown—Kent Constr. Co. Felton, Del., awarded contract by Kent Co., Commrs. to construct roads, at $340,000.

Mass., Boston—Thomas & Murphy Co., Keene, N. H., awarded contr. to build 56,400 ft. state rd. 22 ft. wide, Eastham & Wellfleet Twps., involving 12,900 tons bitum. conc. 56,000 gal. bitum. macadam, 5,200 cu. yds. earth excav. at $166,047.

Mich., Grosse Point (Detroit, P. O.)—G. R. Cooke, Penobscot Bldg., Detroit, awarded contract for grading, shaping and paving 1 mi. St. Clair Ave., involving 18,000 sq. yds. asphaltic concrete on 6-in. concrete fdn., at about $119,000.

Mich., Lansing—Following contracts let for Mich. State trunk line; Oosting & Hofsteen, Holland, rd. in Ottawa Co., Holland-Olive Twp., at $4,390, with F-conc., at $160,579; Thos. E. Currie, Detroit, Macomb Co. Lenox, 4.331 mi. F-conc., at $174,958; J. Orr Standish, rd. in Ogemaw Logan Twp., 3.052 mi. B-gravel, at $40,126; also rd. in Logan-Churchill Twp., B-gravel, 5.470 at $84,007; Jno Meshler, Freeport, rd., in Ionia Co., Campbell Twp., 3.967 mi. of B-gravel at $41,474; Schneider O'Harrow, Lowell, Ionia Co., Lowell-Boston Twp., grading, draining, structures, at $26,230; Hull & Gasner, rd. St. Clair Co., Port Huron, St. Clair, Columbus & Casco Twp. for grading, draining, structs. $140,753.

Mich., Mt. Clemens—Detroit Asphalt Paving Co., 20 McGraw Bldg., awarded contract for grading, draining and surfacing 1.964 miles of Rd., 46, near Richmond, 20-40 ft. wide, involving 26,000 sq. yds. asph. conc. on 7-in. concrete base, at $122,780.

Mo., Jefferson City—Pope Constr. Co. awarded contract to construct 12½ miles bitum. macadam hard-surfaced road in Boonville Special Rd. Dist. at $200,000.

Mont., Helena—Louis Johnson, City awarded contract State Hwy. Comn. for bldg. Helena-to-E. Helena and Jefferson Co. line hwy.; also paving of main street of E. Helena, at $88,000, not including the cement which Comn. will purchase for county and city governments; White, Brown & Leahy, awarded contract for Great Falls-Belt project, at $220,000.

Mont., Helena—B. P. Melchert, Lewistown, awarded contract for surfacing F. A. proj. No. 27, half of the Grand Range-Roundup proj. at $105,365.

Mont., Livingston—C. T. Heaton, Constr. Co. local, awarded contr., for 6-in. plain concrete paving, at $414,000.

Neb., Columbus—Allied Contractors, Inc. 4616 Harney St. Omaha, Neb., awarded contract for 2 miles of F. A. paving. Est. cost $85,000.

N. J., Elizabeth—Standard Bitulithic Co. awarded contr. for repaving Jersey St., at $100,099, Baltic St., at $32,195; South St., at $25,339, John E. Donovan, Summer St., at $42,859 and repaving Maple Ave., from Summer St., to Bayway, at $32,631.

N. J., Freehold—C. G. Julian Engrg. & Contg. Co., 20 Nassau St., New York City, awarded contract for bldg. 1.8 miles Eatontown Blvd., Eatontown to Long Branch, 22 ft. wide, at $105,301.

N. C., Salisbury—R. M. Hudson Co., awarded contract for paving 2.2 miles of streets, 25-27 ft. wide, bitulithic on 5-in. bitum. conc. base, at about $150,000.

O., Jefferson—C. G. Fuller, 139 Mill St., Conneaut, awarded contract for grading and paving 5.8 miles Rime-Morgan Rd., 10 ft. wide, involving 22,539 cu. yds. earth and 60 cu. yds. rock excav., etc., etc. at $169,774.

Okla., Comanche—Municipal Excavator Co., 200 E. Main St., Okla., awarded contr. for paving 15 blocks, at $136,450.

Okla., Mangum—Municipal Excavator Co., Okla. City, Okla., awarded contract for street impvt. dist. No. 1, at $209,890; asph. conc. on conc. base.

Okla., Sallisaw—M. A. Swatek & Co., Okla. City, Okla., awarded cont. for paving in Districts Nos. 2 and 3 in Okemah, Okla., at $120,000.

Pa., Harrisburg—Good Roads Constr. Co. Erie, awarded contr. to construct section of Route 87—approx. 7,300 ft. long and 18 ft. wide— Harbor Creek Twp. Erie Co., at $83,839; one-course rein. conc.; Mangan & Risser, Lebanon, Pa., awarded contract to build sect. of Route 162, Schuylkill Co., at $558,754; abt. 38,315 ft.

Pa., Harrisburg—Following contracts let by Hwy. Comn.: Huntingdon Co., Millcreek Boro., 4,243 ft. to Standard Contg. Co., Altoona, $46,206, Lawrence Co., Pulaski Twp., 28,644 ft., Woods & Golder, New Castle, at $320,331; Fayette Co. Bullskin and Upper Tyrone Twp., to J. I. Dick, Scottdale, at $108,408; Mercer Co., Jefferson, Delaware and Hempfield Twps., 48,465 ft. Donald McNeil Co., Pittsburg, at $385,230; Cambria Co. Allegheny & Cambria Twps. and Ebensburg Boro., 24,431 ft. Polo., Assara, Cresson, at $364,171; Erie Co., Waterford & Summit Twps., 42,900 ft. Carey, Campbell & Co., N. Y. City, at $520,755; Ambler Davis Co., contr. for bldg. 25,911 ft. State hwy. in Horsham & Moreland Twps. Montgomery Co., at $281,406; Wm. C. Evans,

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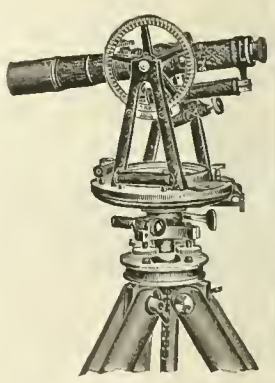

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